measurement SPECIALTIES
PRESSURE SYSTEMS

Model 903X
Pressure Standard & Pressure Calibrator
User's Manual

March 2008

NetScanner™ System

www.PressureSystems.com

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Our Company

Pressure Systems Incorporated, (PSI) develops, manufactures, and services level and pressure measuring instruments where the highest level of traceable accuracy is required for aerospace, industrial, municipal, and environmental applications. Our products have become the world standard for electronic level and pressure measurement and scanning. We are committed to the highest quality design, manufacture, and support of level and pressure instrumentation that is in the best interest of our customers. PSI is an ISO-9001:2000 certified company.

Our Warranty

Pressure Systems, Inc., warrants **NetScanner™ System** products to be free of defects in material and workmanship under normal use and service for one (1) year.

Technical Support

Monday through Friday, during normal working hours, (7:30 am through 5:30 pm, Eastern time) knowledgeable personnel are available for assistance and troubleshooting. Contact the **Applications Support Group** or the **Customer Services Department** at Pressure Systems (**757-865-1243** or toll free **1-800-328-3665**) if your scanner is not operating properly or if you have questions concerning any of our products. E-mail assistance is available by contacting Applications@PressureSystems.com.

Merchandise Return Procedures

If your scanner needs to be returned to Pressure Systems, obtain a Returned Merchandise Authorization (RMA) from the Customer Service Department.

Be prepared to supply the following information when requesting the RMA:

- Part number
- Serial number
- Complete description of problems/symptoms
- **Bill To** and **Ship To** address
- Purchase order number (not required by PSI warranty repairs)
- Customer contact and telephone number

The above information, including the RMA number must be on the customer's shipping documents that accompany the equipment to be repaired. PSI also requests that the outside of the shipping container be labeled with the RMA number to assist in tracking the repairs. All equipment should be sent to the following address:

ATTN: PSI REPAIR DEPARTMENT (7-digit RMA number)
Pressure Systems, Inc.
34 Research Drive
Hampton, Virginia 23666

PSI will return warranty items prepaid via UPS GROUND. If the customer desires another method of return shipment, PSI will prepay and add the shipping charges to the repair bill.

Incoming freight charges are the customer's responsibility. The customer is also responsible for paying shipping charges to and from PSI for any equipment not under warranty.

All products covered under the PSI warranty policy will be repaired at no charge. An analysis fee will be charged to quote the cost of repairing any item not under warranty. If, for any reason, the customer decides not to have the item repaired, the analysis fee will still be charged. If the quote is approved by the customer, the analysis fee will be waived. The quote for repair will be based on the PSI flat rate for repair, calibration, and board replacement. When these prices do not apply, the quote will be based on an hourly labor rate plus parts. All replaced parts are warranted for 90 days from the date of shipment. The 90-day warranty is strictly limited to parts replaced during the repair.

Website and E-Mail

Visit our website at www.PressureSystems.com to look at our new product releases, application notes, product certifications, and specifications. E-mail your questions and comments to us: Sales@PressureSystems.com.

Our Firmware

This manual was prepared for various versions of module firmware as were released at the time of this manual publication. Addenda will be distributed as deemed necessary by PSI. Any questions regarding firmware upgrades may be addressed to the **Applications Support Group**. Firmware revisions, manual addenda, and utility software may also be obtained from the PSI web page at www.PressureSystems.com.

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This document is thoroughly edited and is believed to be thoroughly reliable. Pressure Systems, Inc., assumes no liability for inaccuracies. All computer programs supplied with your products are written and tested on available systems at the factory. PSI assumes no responsibility for other computers, languages, or operating systems. PSI reserves the right to change the specifications without notice.

Chapter 1

General Information

1.1 Description of the Instruments

NetScanner™ System Models 9032 and 9033 are single-point, high-accuracy pressure *standards*. Models 9034 and 9038 are high precision pressure *calibrators* which incorporate *standards*, but have the added capability to *generate* (as well as measure) precise pressures. These units are designed for a variety of laboratory and manufacturing test applications. In this manual they are referred to collectively as 903x modules.

The unique features of the **NetScanner™ System** Pressure Standards and Calibrators are:

- Compact, rugged packaging.
- Absolute and Differential Reference Configurations — The **NetScanner™ System** Pressure Standards and Calibrators utilize resonant quartz pressure standards for absolute measurements and the PSI-developed High Accuracy Silicon Sensor (HASS) pressure standards or 3rd party manufactured digital pressure standards (DPT) for differential measurements.
- High Accuracy — Internal standards provide real-time active control
- Low Thermal Errors — The onboard 32-bit microprocessor performs digital temperature compensation of the standards to reduce thermal errors for operational temperature ranges from 0 to 50ºC.
- Digital I/O Capability — The modules include 4 output signals to drive external solenoids or provide logic outputs and 4 digital inputs for TTL signals or contact closure sensing.
- Ease of Use — Modules have simple command sets and provide engineering unit output. Units may interface directly to a desktop or laptop computer.
- Automatic Pressure Sequencing — Models 9034 and 9038 Pressure Calibrators provide the capability to generate a series of pressures based on preprogrammed values including slew rates and hold times.
- Connectivity — Use of Ethernet communications protocols allows networking of **NetScanner™ System** Pressure Standards and Calibrators over a wide area. Industry standard TCP/IP protocols ensure compatibility with third party hardware and software.

1.2 Options

1.2.1 Pressure Ranges

NetScanner™ System 903x instruments utilize a single, high accuracy pressure transducer. Models 9032 and 9034 contain an absolute pressure transducer, available in ranges from 15 to 750 psia. Models 9033 and 9038 contain a differential pressure transducer which is available from ±1 to ±5 psid. Please consult the Sales Department at Pressure Systems at 1-800-678-SCAN (7226) for availability of other pressure ranges.

1.2.2 Pneumatic Connections

Swagelok™ compression fittings are the standard pneumatic connections for all **NetScanner™ System** instruments (however, other brand names may be used). The number of fittings will vary depending upon the exact model purchased.

9032 Absolute Pressure Standard — incorporates one (1) fitting for input of absolute measurement pressures.

9033 Differential Pressure Standard — incorporates two (2) fittings for the input of differential measurement pressures.

9034 Absolute Pressure Calibrator — incorporates four (4) fittings; the supply pressure, the vent, the reference pressure, and the output pressure. The reference port allows the 9034 Absolute Pressure Calibrator to also be used as a gauge (pseudo-differential) instrument. A software command can instruct the calibrator's standard to read barometric pressure which is then used as the reference to generate gauge pressure outputs. To generate sub-atmospheric pressures, connect a vacuum pump to the VENT/VAC port.

9038 Differential Pressure Calibrator — incorporates four (4) fittings; the supply pressure, the vent, the reference pressure, and the output pressure. A vacuum pump is required to generate negative differential pressures and should be connected to the VENT/VAC port.

1.2.3 Communications Interfaces

NetScanner™ System products support an Ethernet communications interface using layered TCP/IP communications protocols. These layered protocols are supported by an established base of third-party hardware and software. They also define a standard communications packet structure into which 903x module-specific commands and responses may be easily packed. The TCP protocol layer (used by most commands) includes robust packet error detection and correction mechanisms. A simpler UDP protocol layer (part of the TCP/IP suite) is used by some network query and control commands.

1.2.4 Digital I/O Connections

Digital I/O is available on the front panel for user applications. A software command allows each of the user digital outputs, K1-K4, to be independently set or reset. The open collector outputs can drive external solenoids requiring less than 0.5 ampere (amp) or external pull-up resistors can be connected to provide logic outputs. Up to 1 (amp) of 24 VDC power is available for external use. 24 VDC solenoids, requiring less than 0.5 amp may be directly connected to the I/O connector. The output current for each driver should not exceed 0.5 amp and the total current for all four outputs should not exceed 1amp.

A software command is used to read the four user digital inputs, D1-D4. These inputs can be used to sense TTL signals or external pull-up resistors may be added to sense contact closures. Up to 50V may be applied without damage.

Other similar digital I/O "bits" control the internal solenoid valves, K5-K7, and sense their current status. Model 9032 has no internal solenoid valves, though other models have either one or three valves. Under certain conditions, these may be user operated or automatically operated by internal functions.

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Chapter 2

Installation and Setup

2.1 Unpacking and Inspection

The **NetScanner™ System** product family has many components which may be purchased either as an entire system, or as individual pieces of equipment. Before assembling the system, use the shipping bill as a reference to ensure that all parts have arrived. Pressure Systems, Inc., takes no responsibility for equipment that is damaged during shipment. If containers are broken, ripped, or damaged, contact the transportation carrier. If the equipment itself appears to be damaged, contact the Repair Department at Pressure Systems.

Each **NetScanner™ System** module may contain the following minimum components:

- Model 9032/33 or 9034/38 Pressure Standard/Calibrator
- Model 9082 Connector Cable (an optional accessory)
- CD-ROM

2.2 Safety Considerations

Always wear safety glasses when operating this equipment or when working with pressurized lines. Always ensure that high pressure lines are properly secured.

All system power should be **OFF** during installation or removal of any component from the **NetScanner™ System** module. Failure to turn the power to **OFF** prior to installation may cause permanent damage to the module. Use caution and check line voltages before applying power to the module.

2.3 Preparation for Use

2.3.1 Environment

Model 903x Pressure Standards/Calibrators are factory calibrated for use over specified temperature ranges. Operating the instrument outside the calibrated temperature range will result in a loss of measurement accuracy. Operation beyond specified operating or storage temperature ranges may damage the instrument.

Note

WARNING: Exceeding the specified storage or operating temperatures may result in permanent damage.

Operating Temperature Range:
-10 to 60ºC Up to 95% non-condensing humidity
0 to 50ºC Range = 5 psid

Storage Temperature Range:
-20 to 80ºC
0 to 70ºC Range = 5 psid

2.3.2 Power

Models 903x require regulated input voltages of +24 VDC @ 500 mA. The modules internally sub-regulate the +24 VDC to provide the required internal power levels. An output voltage of +24 VDC @ 1ampere is available to control external solenoids. Connecting an external load to this output will increase the power input requirements to +24 VDC @ 1.5amp.

Figure 2.1 shows pin assignments for the module Ethernet Host Port connector. All connections, including power are made through this top panel round, ruggedized connector.

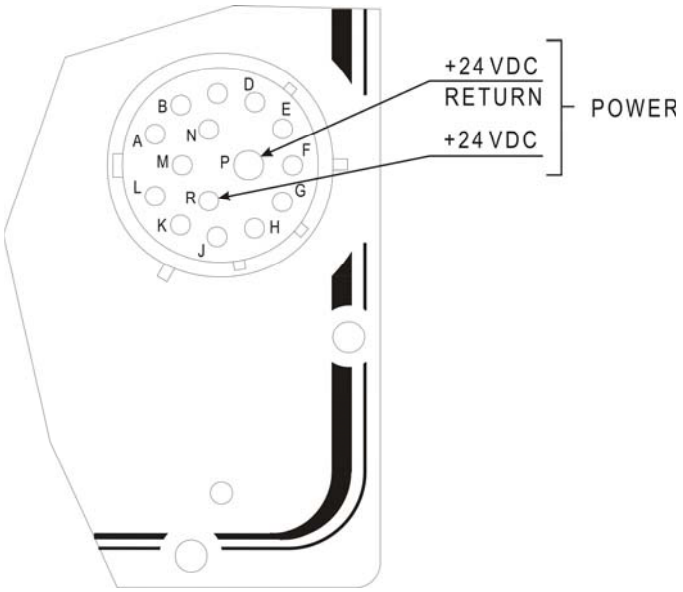

Figure 2.1
Power Pin Assignments

2.3.3 Mounting Dimensions

Panel mounting dimensions for the **NetScanner™ System** pressure standards/calibrators are shown in **Figure 2.2**

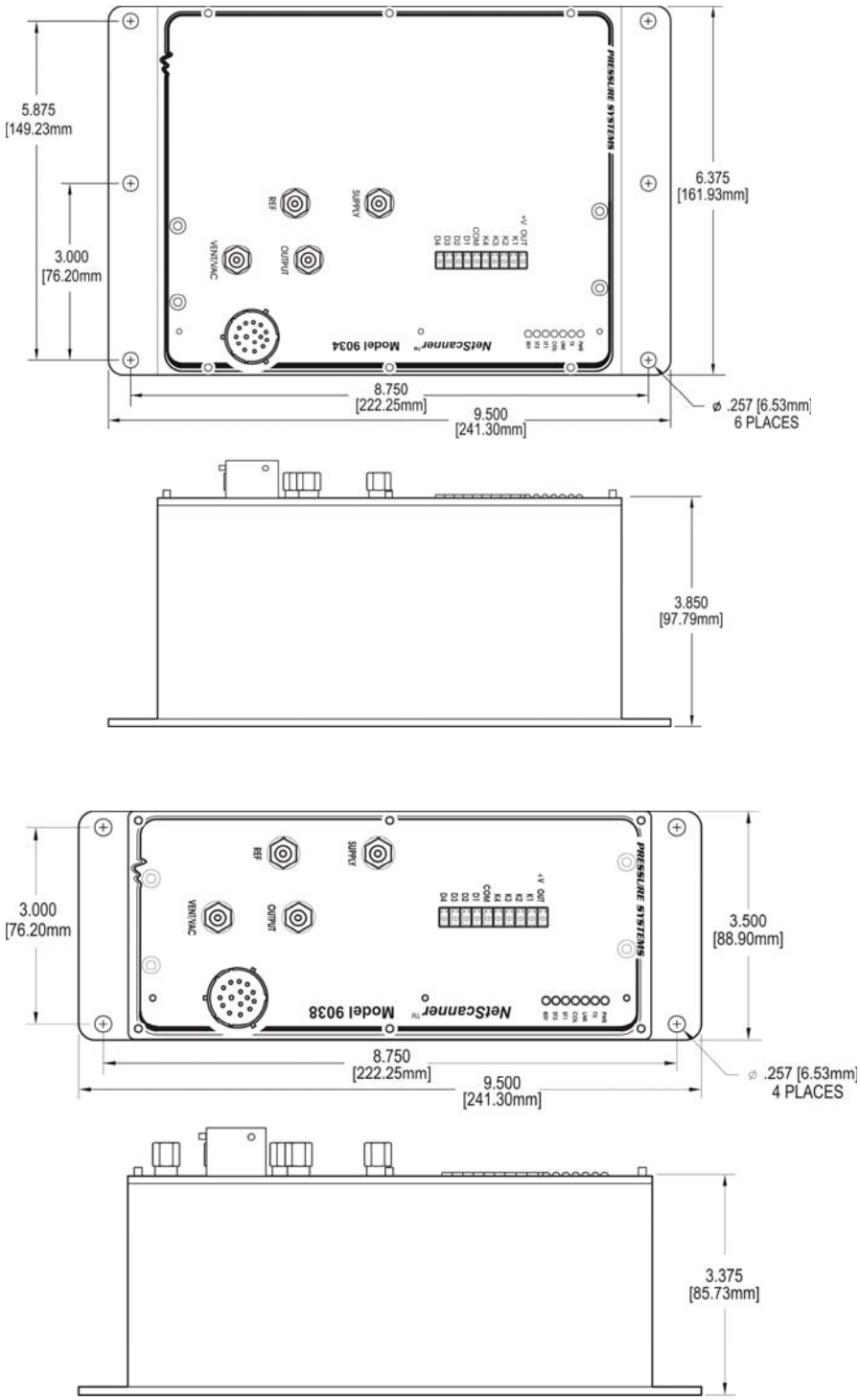

Figure 2.2
Typical Mounting Diagram

2.3.4 Ethernet Host Port Hookup

Every **NetScanner™ System** Pressure Standard/Calibrator contains a Host Port, allowing it to be interconnected in a network with other modules and a host computer. Models 903x series connect through their Ethernet Host Port using TCP/IP transmission protocols.

The Ethernet Host Port of every module, and its host computer, may be interconnected in a "star" network via a standard 10Base-T interconnection hub or through the rear panel of the **98RK Scanner Interface Rack** chassis. These standard hub devices will have their own power requirements. Internal power is supplied by the **98RK Scanner Interface Rack**, which can accommodate up to three (3) externally-mounted pressure calibrators/standards or Intelligent Pressure Scanners. Such a hub treats the host computer connection and all **NetScanner™ System** module connections alike.

Ethernet communications pin assignments for the 903x electrical connector on the instrument's top panel are shown in **Figure 2.3. Figure 2.4** depicts a typical **98RK Scanner Interface Rack** (Ethernet) topology.

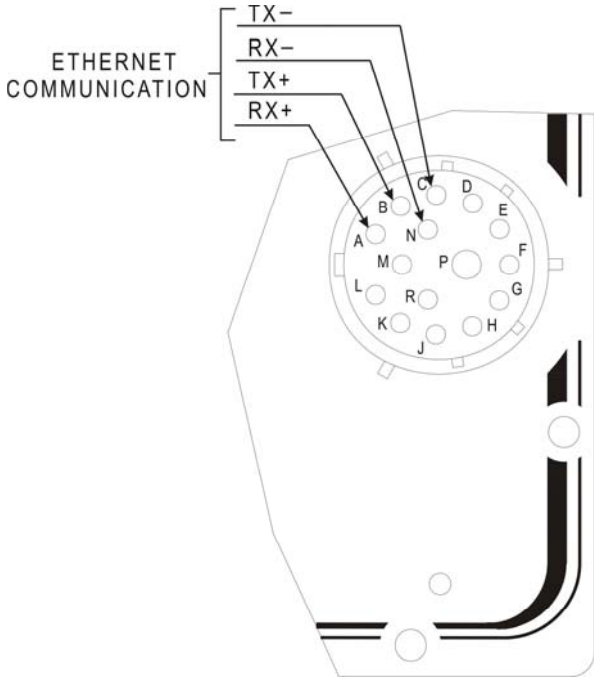

Figure 2.3
Ethernet Host Port Connector Pins

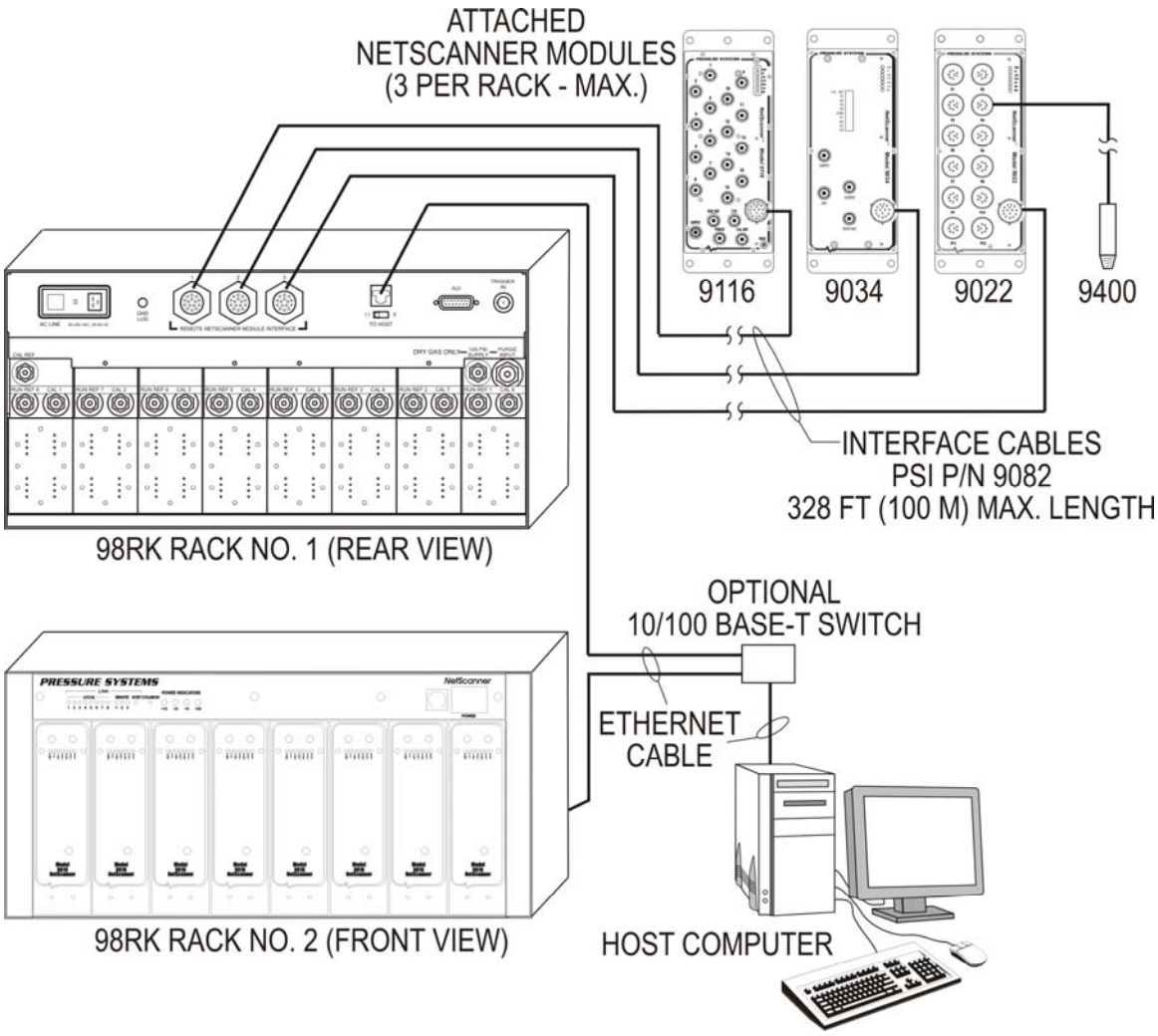

Figure 2.4
Typical Ethernet Topography with 98RK Scanner Interface Rack

2.3.5 Pneumatic Connections

All pneumatic connections to **NetScanner™ System** models 903x modules are found on the instrument top panel as shown in **Figure 2.5**. Connections are through compression fittings or user-supplied fittings using the 1/16" NPT female-threaded tubing plate. ***All pneumatic inputs to these modules should contain only dry, non-corrosive gas.***

- Always wear safety glasses when working with pressurized lines.
- Ensure that user input pressure will not exceed the over-pressure specifications. Applying excessive pressure to measurement inputs can permanently damage pressure transducers.
- Ensure that all tubing material is rated for the expected pressure and environmental conditions. Failure to use the proper tubing material may result in ruptured lines and possible personal injury.

Note

WARNING: Introduction of contaminants or corrosive materials to the module inputs may permanently damage the pressure transducer.

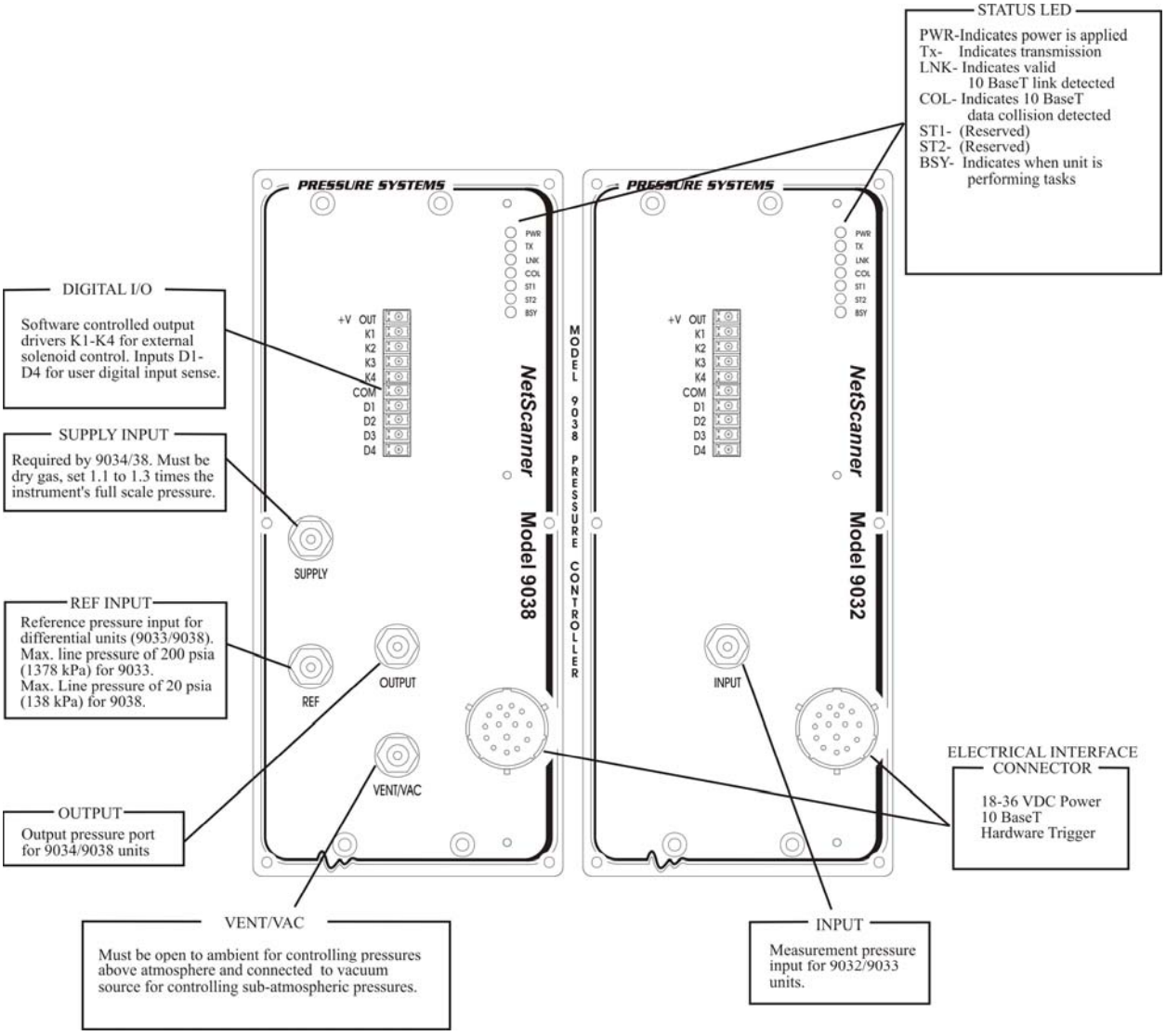
STATUS LED
PWR-Indicates power is applied
Tx- Indicates transmission
LNK- Indicates valid 10 BaseT link detected
COL- Indicates 10 BaseT data collision detected
ST1- (Reserved)
ST2- (Reserved)
BSY- Indicates when unit is performing tasks
DIGITAL I/O
Software controlled output drivers K1-K4 for external solenoid control. Inputs D1-D4 for user digital input sense.
SUPPLY INPUT
Required by 9034/38. Must be dry gas, set 1.1 to 1.3 times the instrument's full scale pressure.
REF INPUT
Reference pressure input for differential units (9033/9038). Max. line pressure of 200 psia (1378 kPa) for 9033. Max. Line pressure of 20 psia (138 kPa) for 9038.
OUTPUT
Output pressure port for 9034/9038 units
VENT/VAC
Must be open to ambient for controlling pressures above atmosphere and connected to vacuum source for controlling sub-atmospheric pressures.
INPUT
Measurement pressure input for 9032/9033 units.
ELECTRICAL INTERFACE CONNECTOR
18-36 VDC Power
10 BaseT
Hardware Trigger
PRESSURE SYSTEMS
NetScanner
Model 9038
MODEL 9038 PRESSURE CONTROLLER
Model 9032
+V OUT K1 K2 K3 K4 COM D1 D2 D3 D4
PWR TX LNK COL ST1 ST2 BSY
SUPPLY
REF
OUTPUT
VENT/VAC
INPUT

Figure 2.5
Module Pneumatic Connections

2.4 The 9032 Quartz Absolute Pressure Standard

The 9032 Pressure Standard measures a single absolute pressure. Connect the measurement input pressure directly to the single input fitting on the top plate. The tubing connected to this fitting should be rated for the full scale input pressure of the module. The pneumatic diagram of the 9032 is shown in **Figure 2.6.** To protect the quartz standard, an internal relief valve vents the input when it exceeds 110% of the full scale pressure range.

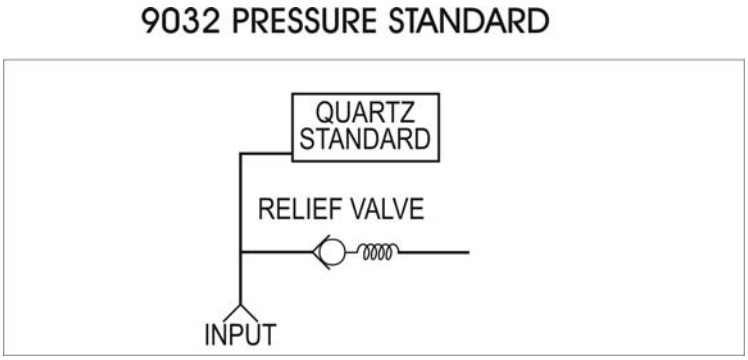

Figure 2.6
9032 Pressure Standard

2.5 The 9033 Differential Pressure Standard

The 9033 Pressure Standard measures a single differential pressure. Connect the differential measurement's high side to the **INPUT** port on the top plate and the low side to the **REF** port. The tubing connected to this fitting should be rated for the full scale input pressure of the module. The pneumatic diagram of the 9033 is shown in **Figure 2.7**. The bi-directional relief valves vent if either input exceeds the other by 110% of the full scale pressure range. The Re-zero solenoid allows the user to minimize zero errors due to line pressure, temperature, and drift with time.

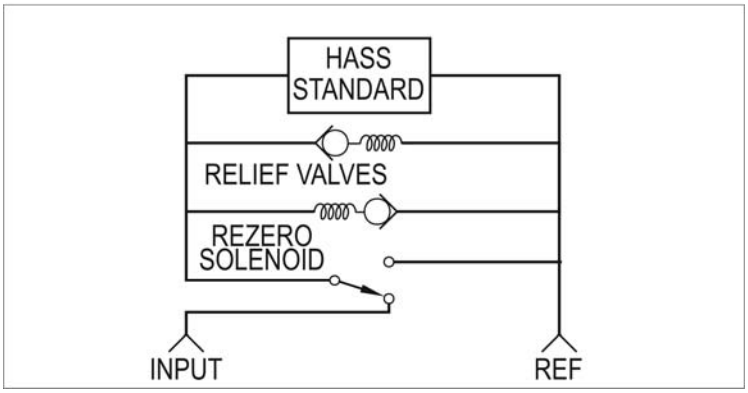

Figure 2.7
9033 Pressure Standard

2.6 The 9034 Quartz Absolute Pressure Calibrator

The absolute reference 9034 generates pressures between 5%-100% of the instrument's full scale pressure range. A digitally controlled pneumatic servo valve modulates the mix of supply/vent pressure to its output, allowing pressures to be generated from near vacuum to the full scale of the instrument. A quartz pressure standard measures the servo valve's output when the Generate valve is connected (flowing). The microprocessor adjusts this valve to set the requested pressure. The instrument may also be used in a measurement mode by connecting the pressure to be measured to the output port and disconnecting the normally-connected Generate valve. The pressure relief valve is designed to vent at 110% of the instrument's full scale pressure range. Prior to shipment, Pressure Systems calibrates each pressure standard with an NIST traceable standard. The transducer is calibrated in the **NetScanner™ System** module so that the entire system is calibrated, not just the transducer. If the user requires another calibration, follow the procedure in **Chapter 4** of this manual.

To complete a successful installation, auxiliary equipment, such as the air supply and vacuum pump, must be considered. The pneumatic diagram of the 9034 is shown in **Figure 2.8**. Modules with a full scale output above 100 psia do not contain an internal supply regulator.

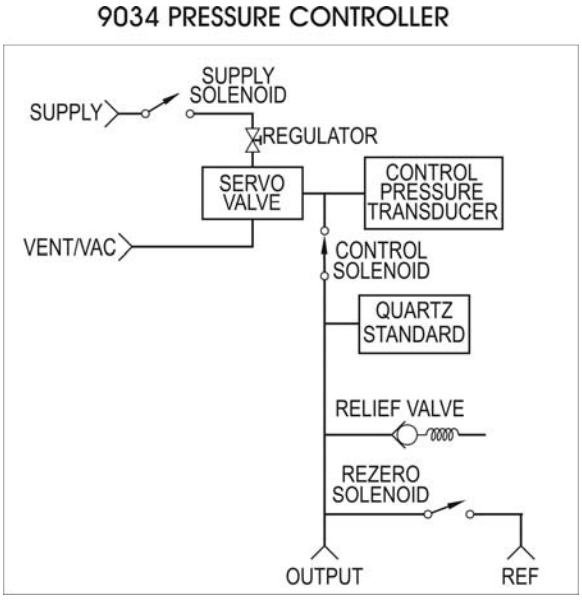

Figure 2.8
9034 Pressure Calibrator

2.6.1 Pneumatic Connections to the 9034 Pressure Calibrator

2.6.1.1 SUPPLY Port

Connect a clean dry air supply to the **SUPPLY** port on the top plate. Medical-quality dry, compressed air or nitrogen is recommended. When using non-bottled air/N_2, the source should be filtered of particles above 10 microns, 99.9% free of oil mist, and the dew point maintained below -25ºC. All 9034 calibrators with an output pressure range of 100 psia or below contain an internal pressure regulator. For these units, the user should maintain the supply pressure at least 10 psi above the full scale output pressure but less than the regulator's maximum input pressure of 125 psi. For 9034 calibrators with a full scale output pressure above 100 psia, the user should regulate the supply pressure between 1.1 and 1.5 times the full scale output pressure.

Note

NOTE: Any contaminants in the source air may affect the operation or possibly damage the module.

2.6.1.2 VENT/VAC Port

To generate sub-atmospheric output pressure, connect the **VENT/VAC** port to a vacuum supply. If sub-atmospheric pressure outputs are not required, leave the **VENT/VAC** port open to the atmosphere.

The number of pressure calibrators supplying sub-atmospheric calibration pressures will determine the pumping capacity required. A vacuum pump with a capacity of 160 liters per minute (LPM) is recommended. A 160 LPM pump generally has sufficient capacity to operate up to five pressure calibrators. A 60-75 LPM pump will operate systems with one or two pressure calibrators. The user should determine the limitations of each setup, especially if multiple modules are connected to the same vacuum pump.

During pressure generation, air flows from the **SUPPLY** port to the **VENT/VAC** port. Each pressure calibrator draws air through the **SUPPLY** port and vents any excess through the **VENT/VAC**. The amount of flow depends on the full scale pressure range and the output pressure. The user must provide sufficient flow capacity to the **SUPPLY** port and must not obstruct the **VENT/VAC** port. Back pressure on the vent from a blockage or combining of the vents from different calibrators, will affect the operation. These vents should NOT be manifolded together with tubing (for example, to route the venting air out of the control room). Use ONLY individual tubes for this purpose.

2.6.1.3 REF Port

The **REF** port allows the 9034 to generate an output pressure relative to the reference when operating in a pseudo-differential mode. Connect the **REF** port to the reference pressure source. It is generally acceptable to leave the **REF** port open to atmosphere for most applications which use atmospheric pressure as the reference.

2.6.1.4 Differential Mode

All 9034 resonant quartz transducers measure absolute pressure. However, the user can operate in a pseudo-differential mode and generate pressures relative to a reference pressure. In this mode, the module measures the reference pressure (by connecting the Re-zero valve) and stores its value. To generate differential pressures, the stored reference pressure is added to the requested pressure. When reading differential pressures, the stored reference pressure is subtracted from the measured pressure.

When operating in the pseudo-differential mode, all pressures specified by the user must be in differential units. The sum of the reference pressure and requested pressure cannot exceed the range of the resonant quartz.

Generating zero differential pressure is a special case. When zero pressure is requested in the differential mode, the calibrator pneumatically shunts the output port to the reference port by automatically energizing the Zero solenoid.

2.6.1.5 Absolute Mode

When operating the 9034 calibrator in the absolute mode, specify all pressures in absolute units. The reference port is not used in this mode (i.e., Zero valve always remains unconnected [solenoid not energized]).

2.6.1.6 Over-Pressure Protection

Each 9034 calibrator has a pressure relief valve to protect its resonant quartz transducer. The relief valve is factory set to release any pressure that exceeds 110% of the unit's full scale pressure range. Although the relief valve is designed to protect the quartz transducer against accidental over-pressure, exceeding the over-pressure specification may result in permanent damage.

2.7 The 9038 Differential Pressure Calibrator

The differential reference 9038 is designed to generate pressures between vacuum and ±100% of the instrument's full scale pressure range. A digitally-controlled pneumatic servo valve modulates the mix of supply/vent pressure to its output, allowing pressures to be generated relative to the reference pressure. The differential high accuracy pressure standard is measured under microprocessor control to maintain the desired generated pressure when the Generate valve is connected (flowing). The Re-zero solenoid allows the user to execute, on demand, a pneumatic re-zero of the pressure standard. This standard may also be used in a measurement mode by disconnecting the normally-connected Generate valve and applying the pressure to be measured to the output port. The instrument is protected by bi-directional relief valves designed to vent whenever either the output or reference port exceeds the other by 150% of the full scale pressure. The pneumatic diagram is shown in **Figure 2.9.**

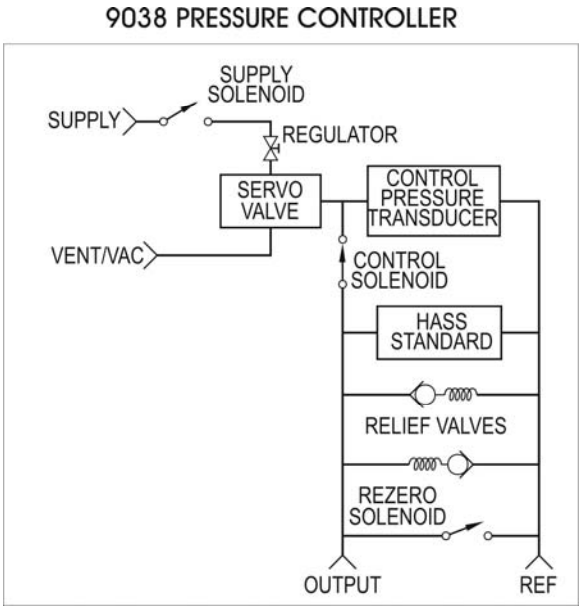

Figure 2.9
9038 Pressure Calibrator

2.7.1 Pneumatic Connections to the 9038 Pressure Calibrator

2.7.1.1 SUPPLY Port

Connect a clean dry air supply to the **SUPPLY** port on the top plate. Medical-quality dry, compressed air or nitrogen is recommended. When using non-bottled air/N_2, the source should be filtered of particles above 10 microns, 99.9% free of oil mist, and the dew point maintained below -25ºC. All 9038 calibrators with an output pressure range below 100 psid contain an internal pressure regulator. For these units, the user should maintain the supply pressure at least 10 psi above the full scale output pressure but less than the regulator's maximum input pressure of 125 psi.

2.7.1.2 VENT/VAC Port

To generate sub-atmospheric output pressure, connect the **VENT/VAC** port to a vacuum supply. If sub-atmospheric outputs are not required, leave the **VENT/VAC** port open to the atmosphere.

The number of pressure calibrators supplying sub-atmospheric calibration pressures will determine the pumping capacity required. A vacuum pump with a capacity of 160 liters per minute (LPM) is recommended. A 160 LPM pump has sufficient capacity to operate up to five pressure calibrators. A 60-75 LPM pump will operate systems with one or two pressure calibrators. The user should determine the limitations of each setup, especially if multiple modules are connected to the same vacuum pump.

During pressure generation, air flows from the **SUPPLY** port to the **VENT/VAC** port. Each pressure calibrator draws air through the **SUPPLY** port and vents any excess through the **VENT/VAC**. The amount of flow depends on the full scale pressure range and the output pressure. The user must provide sufficient flow capacity to the **SUPPLY** port and must not obstruct the **VENT/VAC** port. Back pressure on the vent from a blockage or combining of the vents from different calibrators, will affect the operation. These vents should NOT be manifolded together with tubing (for example, to route the venting air out of the control room). Use ONLY individual tubes for this purpose.

2.7.1.3 REF Port

The reference (**REF**) port provides the reference pressure for the differential output. Connect the **REF** port to the desired reference source. Do not exceed the maximum pressure of 20 psia. Leave the **REF** port open to atmosphere for most applications which use atmospheric pressure as the reference.

The 9038 differential pressure calibrator is capable of operating at elevated reference pressure (line pressure). Because operation at elevated reference pressure may adversely affect the calibrator's ability to accurately generate pressure with atmospheric reference, PSI offers elevated reference pressure as a no cost option. Standard 9038 differential pressure calibrators are factory set for atmospheric reference operation. Contact the PSI Sales Department to specify your exact line pressure operating requirements.

2.7.1.4 Operation in Differential Mode

The 9038 operates in the **DIFFERENTIAL** mode ***ONLY***. The internal pressure transducer is a true differential standard. During a re-zero operation, the calibrator pneumatically shunts the output port to the reference (by connecting the Re-zero valve) and measures the zero offset. After the re-zero, the calibrator subtracts this offset from the measurements. When zero pressure is requested, the calibrator pneumatically shunts the output port to the reference port. The user must specify all pressures in differential units.

2.7.1.5 Operation in Absolute Mode

The 9038 differential pressure calibrator cannot operate in absolute mode.

2.7.1.6 Over-Pressure Protection

Each 9038 calibrator has two relief valves to protect its internal differential transducer. These valves are factory set to release any differential pressure that exceeds 110% of the unit's full scale pressure range. Although the relief valves are designed to protect the transducer against accidental over-pressure, exceeding the specification over-pressure may result in permanent damage.

2.8 Operating Considerations

2.8.1 Operational Effects of Leaks

The most critical item for successful operation of any one of these modules is the elimination of leaks. Each module has been tested for internal leaks and calibrated with an air piston standard. 9034 and 9038 modules set pressures accurately but do not have remote sensing capability. External leaks can produce unpredictable results. Refer to **Chapter 6, Paragraph 6.4** for a leak check procedure.

2.8.2 Locating and Fixing Leaks

The most common leaks are found in the external connections. The Swagelok™ fittings on the unit need only be finger tight plus ½ turn with a wrench. Inspect the fitting and replace it where necessary when a leak is suspected or found. Over-tightening will damage the fitting.

2.8.3 Power-up Checks and Self-Diagnostics

Upon power-up, the module firmware performs internal self-diagnostic checks and illuminates the **OK** LED if no errors are detected. The user may interrogate the results of these tests with the **'Read Status'** command described in **Chapter 3.** The module displays several types of errors by blinking the **OK** LED. If the **OK** LED does not remain illuminated contact PSI's Repair Department. An A/D hardware failure is indicated by one blink on the **OK** LED. The blink pattern will repeat after a five second delay.

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Chapter 3

Programming and Operation

3.1 Commands and Responses

3.1.1 Introduction

This chapter describes all *commands* a host computer program may send to a **NetScanner™ System** Intelligent Pressure Standard/Calibrator module, as well as the data or status *responses* returned by the module. Most applications require working knowledge of only a small number of these commands. Most commands apply to both types of modules. Models 9032 and 9033 *standards* and models 9034 and 9038 *calibrators* use the TCP/IP protocols to communicate with their host computer via Ethernet (10-Base-T) interfaces.

3.1.1.1 TCP/IP Protocols

The TCP/IP protocol suite is a well-established set of rules for communicating over a network (LAN, intranet, or internet), and is independent of the network's physical medium. Other useful protocols, such as UDP, are included within the TCP/IP suite. Models 903x use TCP/IP protocols for most commands and responses since the TCP layer provides a robust error detection and correction layer. However, a few network query and control commands use the simpler "connectionless" UDP/IP protocols.

Using the underlying basic IP protocol, the host computer and interconnected modules are all "peers" that can all communicate equally. Each "peer" must have its own unique "logical" *IP Address* (as well as its own unique "physical" *Ethernet Address*). Any "peer" may initiate transmissions without permission from the receiver. In the **NetScanner™ System** implementation, the host computer is normally a *client* and generally initiates most transmissions by sending commands to the modules, which are normally *servers*. A maximum of 255 modules are easily addressed by varying only the low-order byte of a typical IP Address. Many more modules may be addressed by also changing the "network" portion (high-order 3 bytes) of the IP address.

A "peer" may be initially addressed by its IP address in *xxx.xxx.xxx.xxx format* or by use of a predefined *logical name* that allows its *IP Address* to be looked-up in the sender's database or in a central network server's database. **NOTE:** Use of these *logical* names requires that they be predefined in a data base used by the host operating system.

Before the host computer and any module can communicate with TCP/IP protocol, the host (*client*) must request a *connection* be established with the module (*server*). Each module expects all such requests for *connection* to be requested by its *IP Address*, and directed to "well-known" port 9000. After the connection is made, a *socket* is established as a logical handle to this connection. The host and module may then communicate, via this *socket,* by writing standard commands and reading standard module responses. This can continue indefinitely until the connection is formally closed (or power is lost at host or module). The host and module may also communicate in a limited fashion *without a connection*, using the UDP/IP protocols. In this case the host broadcasts commands to port 7000 and the module broadcasts responses via port 7001. Only a few network control commands use UDP/IP.

NOTE: After the host disconnects from module, the host must wait 10 seconds before attempting to reconnect to the module.

3.1.2 Commands

The commands used by all 903x modules consist of short strings of ASCII characters. The TCP/UDP/IP protocols used allow for the transfer of either printable ASCII characters or binary data. When using certain command formats, binary data values are often converted to ASCII-hex representations. Such hexadecimal parameters may include the ASCII number characters '0' through '9' and the *uppercase* ASCII characters 'A' through 'F'. These hex values may externally represent internal bit maps of individual options — or actual internal integer or floating point (IEEE) binary data values. In other cases (see optional *format 7* below) binary data may be transmitted directly as 4-byte (32-bit) big-endian binary values without any formatting change.

3.1.2.1 General Command Format

A typical TCP/IP command (contained in the data field following a TCP packet header) is a variable-length character string with the following general fields:

- a 1-character *command letter (c)*,
- an optional *position* field *(pppp)*, a variable length string of hexadecimal digits,
- a variable number of *datum* fields (*dddd*): each a variable length string, *normally* formatted as a decimal number (with a leading *space* character, and with or without *sign* and/or *decimal point*, as needed).

Using brackets *([ ]*) to show optional elements, and ellipsis (...) to show indefinite repetition, a typical TCP/IP command may be viewed schematically as follows:

"*c[[[[p]p]p]p][dddd[dddd]...]*"

From this schematic, it should be clear that the *command letter (c)* is required, the *position* field *(pppp)* immediately follows it, and may have 0, 1, 2, 3, or 4 characters, and there may be zero or more *datum* fields *(dddd), as required*. For simplicity, the variable length nature of *each " dddd"* string is not shown [with brackets] above, but the required leading space character is shown. The position field is similarly simplified (as just *"pppp"*) below.

A typical UDP/IP command (contained in the data field following a UDP packet header) is also a variable length character string, but has a simpler format. Generally, it has a variable length *command string (cccccc)*, followed by one optional *datum (dddd)* field (preceded by one space character):

"cccccc[dddd]"

Since there are only a few simple UDP/IP commands, all references to *commands* below should assume TCP/IP commands, unless otherwise indicated.

3.1.2.2 Command Field

All 903x modules recognize the TCP/IP commands beginning with letters 'A,' 'B,' and 'p' through 'w', when a connection is established with the host. They also recognize the UDP/IP commands beginning with "psi" anytime a module has power. All commands are functionally summarized in **Section 3.1.4** and detailed in reference **Section 3.2.**

3.1.2.3 Position Field

For some commands, the *position* field *(pppp)* may be broken into other distinct independent subfields (e.g., *xxyyzzf*) and these subfields may or may not relate to any *datum* fields. In other commands, there may be a 1-to-1 correspondence between '1' bits in the *position* field (viewed as a binary bit map expressed as a hex number) and the number of *datum* fields that follow it (or the number of *datum* fields returned in the command's response). The bit map form is explained below.

All **NetScanner™ System** Intelligent Pressure Standards/Calibrators may contain up to a maximum of sixteen (16) separate input/output channels. When commands affect certain channels in the module, the *position* field is used to identify those channels as bits in a bit map. The Model 903x series has only one EU pressure channel (Channel 1) which provides the current value of the high-accuracy pressure standard's measurement. For maintenance purposes, other channels (2-16) may provide various internal measurements. If a channel's corresponding bit in the *position* field is set to a one (1), then that channel is affected by the command. The least-significant (right-most) bit 0 corresponds to channel 1, and the most-significant (left-most) bit 15 corresponds to channel 16. For each 903x module the *position field* will have up to four (4) characters (or 16-bits) maximum. See the example below, where only channels 16 and 1 are selected:

Bit #	**15**	14	13	12	11	10	9	8	7	6	5	4	3	2	1	**0**
Chan #	**16**	15	14	13	12	11	10	9	8	7	6	5	4	3	2	**1**
Binary	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hex	8				0				0				1			

NOTE: A *position* field bit map may specify the number and order of *datum* fields that follow it (if command writes data to module). It may also specify the number and order of *datum* fields returned in the command's response (if command reads data from module). In either case, the order of the *datum* fields is from highest requested channel number to lowest requested channel number.

When *all* applicable bits are set in the *position* field (i.e., FFFF for 16-channel module), it specifies *all channels*. Alternately, some commands allow a *missing position field* to designate *all channels*, but only when there are no other parameters following the *position field* in the command. Optionally, the hex *position field* may be reduced to 3, 2, or 1 characters when no channel bits are set (1) in the discarded high-order hex digits (nibbles).

Table 3.1: 903x Channels in Position Field

Bit	Channel	Definition	
		Model 9032/9034	**Model 9033/9038**
0	1	EU Pressure from Standard (psi)	
1	2	N/A	raw pressure (counts)
2	3	N/A	raw temperature (counts)
3	4	N/A	raw reference (counts)
8	9	N/A	raw zero (counts)
9	10	raw pressure (counts)	N/A
10	11	raw temperature (counts)	N/A
15	16	EU Transducer temperature (^{N}C)	

3.1.2.4 Datum Fields

Any *datum* fields in a command generally contain data to be sent to the module, usually specified by a *position* field bit map. In some commands (when data are to be received from a module instead) no datum fields are required in the command itself, but the *position* field bit map is still used to specify the order that data are returned in the command's response. In either case, the order bits are set (to 1) in the *position* field bit map (highest channel # to lowest channel #, left to right) is the order these datum fields are received or sent.

3.1.2.5 Format Field

Some commands, that either send data to a module (as command parameters), or cause the host to receive data (via command's response), have an extra *format* parameter *(f* character) appended to (or specified in) the *position* field. This parameter, when specified (or implied by default), governs how internal data are converted to/from external (user-visible) form.

- The most common format (*f=0)* causes each datum (in command or response) to be a decimal number externally (with optional sign and decimal point as needed). Internally, the module sets/obtains each converted datum to/from a single (32-bit) IEEE float.

- Some formats (*f*=1, 2, 5) encode/decode the internal binary format to/from ASCII hexadecimal external form. Some of these formats provide an external hex bit map of the internal binary value (float or integer as appropriate). Format 5 may encode/decode the internal float value to/from an *intermediate* scaled binary integer (e.g., float value * 1000 into integer, then to a hex bit map in a response (reversed in a command datum conversion)).

- A special "external binary" format (*f*=7) may be used by some commands to accept/return binary data directly from/to the user command/response. Such values are not user-readable in their external form, but provide highly compact storage without any accuracy loss due to formatting.

See the individual command descriptions for the formats a particular command recognizes.

3.1.3 Responses

Four (4) types of responses can be returned from a **NetScanner™ System** Intelligent Pressure Standard/Calibrator module:

- an ***Error*** response,
- an ***Acknowledge*** response,
- an ***Acknowledge with Data*** response, or
- a Network Query response.

The first three may be returned by TCP/IP commands, the latter from a UDP/IP command.

The error response consists of the letter 'N' (for NAK, or negative acknowledge), followed by a two-digit hexadecimal error code. Error codes that can be returned from a **NetScanner™ System** Intelligent Standard/Calibrator module are shown below in **Table 3.2**.

Table 3.2: Error Codes

CODE	MEANING
00	(Unused)
01	Undefined Command Received
02	Not Used in TCP/IP protocol
03	Input Buffer Overrun
04	Invalid ASCII Character Received
05	Data Field Error
06	Not Used in TCP/IP protocol
07	Specified Limits Invalid
08	NetScanner™ System error: invalid parameter

The *Acknowledge* response is returned from a module when a command is received that requires no data to be returned, and no error is detected. It indicates successful parsing and execution of the last received command. It consists only of the letter '**A**' (for ACK, or acknowledge).

The *Acknowledge with Data* response is returned when a module receives a command requesting data. **NetScanner™ System** modules will typically return only the requested data values. The data in the response can be of variable length, depending on the number of channels and data format requested. **These data are returned in the order of highest requested channel number to lowest requested channel number.** For **NetScanner™** modules (with Ethernet host interface) no letter 'A' actually begins this response. Each response datum (including first) may begin with at least one *space* character (except when format 7 is specified).

The Network Query response is only returned for the ***Network Query*** ("psi9000") UDP/IP command. It returns an ASCII string with a series of "comma-separated" data fields. These uniquely identify the module that responded to the query (IP Address, Ethernet Address, module type, serial #, etc.). All other UDP/IP commands return *no* response.

3.1.4 Command Summary

All commands applicable to **NetScanner™ System** Intelligent Pressure Standards/Calibrators are *summarized* in the following table (**Table 3.3)**.

Table 3.3: 903x NetScanner™ Commands

type	command id	function
TCP/IP Commands	A	Power-up Clear
	B	Reset
	c	Define/Control Host Streams (6 sub-commands)
	p	Write High Precision Data
	q	Read Module Status
	r	Read High Precision Data
	u	Read Internal Coefficients
	v	Download Internal Coefficients
	w	Set Operating Options
UDP/IP Commands	psi9000	Query Network
	psireboot	Reboot Specified Module
	psirarp	Change Specified Module's IP Address Resolution method (then Reboot)

3.1.5 Functional Command Overview

The various **NetScanner™ System** commands are best introduced by classifying them into functional groups and then describing how each function is carried out in a typical system. The following functions are defined by 903x module commands:

- Start-up Initialization
- Reading/Writing of Status/Operating Parameters
- Calibration Accuracy Adjustment
- Acquisition/Delivery of Data to Host
- Controlling Pressures Generated (by calibrators)
- Network Query and Control

Please look back to **Table 3.3**, labeled **903x NetScanner™ Commands**, for a quick-look summary of all commands available to **NetScanner™ System** Intelligent Pressure Standards/Calibrators. Each command may be referenced by both its *function* and by its *command id* in the functional discussion sub-sections below.

The ***Detailed Command Description Reference*** immediately follows this overview in **Section 3.2**, with each command description occupying a page (or more if necessary). Command descriptions in this section (as in the table) are ordered first by *"type"* (TCP or UDP) then by *"command id" (*commands having *UPPERCASE* letters (***A ... Z***) first, followed by commands having *lowercase* letters (***a ... z***)).

3.1.5.1 Start-up Initialization

Since power supplies may be distributed widely across a network of modules and host computer(s), it is not uncommon for modules (singly or together) and the host to lose power independently. Thus, their power may be restored at different times. Start-up initialization, for every module, must be performed when its power is restored, as each module enters default states after power-up, which may not be the state the host computer had previously been operating it. Any previous TCP/IP socket connection is also lost after power failure and must be re-established between host and module before any TCP/IP commands can be recognized by the module. These commands are generally used to detect start-up initialization or to force reset, after which other commands may be used to restore the original operating condition.

In the **NetScanner™ System** module command structure, the ***Power-Up Clear*** (**'A'**) command may be used as a simple 'NOP' command to elicit a known response from a module. Although this causes no internal function within the module, it will result in an acknowledgment being returned to the host computer to verify proper communications.

At any point during module operation, the ***Reset*** (**'B'**) command may be used to return any module to its default "reset" state. If the module is then required to enter any other states (that were previously programmed for it by the host), the host must then restore these states accordingly using the appropriate commands. This reset simply returns internal software parameters to a default state; it will not close the existing TCP/IP socket.

The ***Set Operating Options*** (**'w'**) command has many purposes, but may first be utilized during the module initialization stage. It may also be executed at any time during data acquisition.

The ***Network Query*** ("psi9000") UDP/IP command may be used (at any time) to make each **NetScanner™** module on the network identify itself to the host(s).

3.1.5.2 Commands for Data Input/Output

After power-up, all **NetScanner™ System** modules will begin to scan their transducer channel(s). These data are stored in an internal buffer, available for retrieval by the host computer. Scanning will occur at the module's maximum internal rate, with the *number of samples averaged* specified as an option changeable by the ***Download Internal Coefficients*** (**'v')** command (see array 02, indexes 07 & 08). Engineering Units (EU) conversion of the scanned channel(s) is accomplished using thermal correction data extracted from each transducer at power-up. While scanning, the module will automatically monitor the attached transducer's temperature, correcting engineering unit output for any temperature affects.

All **NetScanner™ System** models effectively defer the host computer's decision of "which channels of data do I want" until that time when the host chooses to send read commands to actually retrieve the desired data from the latest "buffered copy" of the continuously scanned, averaged, and engineering-unit-converted data. The command ***Read High Precision Data*** **('r')** is used to retrieve the desired engineering unit data from all 903x modules.

The user may command 9034 and 9038 *calibrator* modules to set pressures. The command ***Write High Precision Data* ('p')** is used for this purpose. The 9032 and 9033 *standard* modules ignore this command.

3.1.5.3 Other Functions

Some commands may be used at any time to obtain information about the internal setup of a module. The ***Read Module Status* ('q')** command is an example. Also, the ***Set Operating Options* ('w')** command, although generally used after power-up reset, may also be used at other times as well to change system operation.

3.1.5.4 Network Query and Control Functions

A special subset of three (3) UDP/IP commands can be executed at any time power is applied to the module (i.e., a host socket connection is not necessary). Each such command should be broadcast via Port 7000, and the module(s) may broadcast a response via Port 7001.

Only one of these commands actually returns a response. This is the ***Network Query* ("psi9000")** command. The others cause the module to be re-booted, therefore no response is possible. One changes the way the module gets its IP address assignment (i.e., dynamically from a server or statically from (initially factory set) internal non-volatile storage).

3.2 Detailed Command Description Reference

All commands applicable to the various **NetScanner™ System** Intelligent Pressure Calibrators/Standards are described on the following pages. They are summarized in **Table 3.3** above.

POWER UP CLEAR (Command 'A')

Purpose: This command has no internal module affect. It is used as a simple method to verify proper communications to the **NetScanner™ System** module.

Command	"**A**" 'A' is the *command letter*
Response	"**A**" 'A' is the *acknowledge* letter

Description: The 903x modules do not return a 'Power-Up Clear Expected' error. This is due to the reset notification mechanisms that are part of the TCP/IP protocol. Therefore, it is a NOP command generally used as a simple mechanism to verify proper communications with a module.

Example:

- Send TCP/IP command to module (via its open socket) to acknowledge module power on:

  "**A**"

  Read following response:

  "**A**"

RESET (Command 'B')

Purpose: Instructs the module to reset internal operating parameters and to set all internal control variables to their default "reset" state (see description below). The current TCP/IP socket connection will remain open. Execution after a power off/on cycle is optional (unnecessary)

Command	"**B**" 'B' is the *command letter*
Response	"**B**" 'B' is the *acknowledge* letter

Description: The **NetScanner™ System** module returns to the following "reset" states if this command is executed:

- All solenoids are de-energized (valves all set to normal states which are mostly *unconnected*, except the GENERATE valve which is *normally connected* when its solenoid is de-energized).

Example:

- Send TCP/IP command to module (via open socket) to set reset defaults:

  "**B**"

  Read following response:

  "**B"**

DEFINE/CONTROL HOST STREAM (Command 'c')

Purpose: Defines and controls the delivery of any of up to *three* concurrent high-speed *autonomous data streams* to the host computer. Such *data streams* (also known as *scan lists* when controlled by hardware trigger) may be delivered "continuously" without bound (i.e., until a command explicitly stops them), or be delivered in a "limited" amount (i.e., until a pre-specified fixed number of data packets have been generated). Each packet delivered may be synchronized by a user-supplied " hardware trigger" or each packet may be delivered periodically as synchronized by an internal software clock. These concurrent host streams are an alternate method of acquiring/delivering data rather than using the ***Read High-Precision Data*** (**'r'**) command.

Host data streams, once activated in a module, deliver a sequence of TCP/IP data packets *autonomously* to the host (i.e., without host having to send any particular command to the module to request each packet).

Various *sub-commands* (described on following pages) define and control all stream options, and use the following general **'c'** command format.

Command	"**c *ii*[*dddd*]...** " 'c' is the *command* letter. ' *ii*' is a *sub-command* index (augment code) preceded by a *space* character. ' *dddd*' are optional *datum* fields, each preceded by a *space* character, as per augment code *ii.* **NOTE: all parameters are separated by a *space*.**
Response	Depends upon particular sub-command (*ii*) sent. See below.
Autonomous Packet	Depends upon particular sub-command (*ii*) sent. See below.

Description: The firmware of a Model 903x module, once fully operating after startup, *continuously* scans and converts data for its single *EU pressure* and EU temperature *input channel* (from its particular Quartz *absolute standard* or *differential standard*). It also scans and stores other intermediate internal "raw" data forms of the pressure and temperature channels. The result of such free-run scanning is a continuously-updated *available data buffer*. Pressure data are scanned more frequently than temperature data, however. This buffer is available to *three (3)* concurrent host data delivery tasks, or available to the standard data acquisition command of the module (i.e., the **'r'** command). Each host delivery task can grab selected data values from the *available data buffer* and deliver them to the host in its own programmable data stream. Such streams are a sequence of TCP/IP packets that autonomously arrive in the host, as long as the host processes them in a timely fashion, thus maintaining enough TCP/IP buffering space to hold them as they arrive. If streams are defined to occur at rates that are too high, the host could be easily overwhelmed.

Special augments of this command called sub-commands (distinguished by first parameter *ii*) can configure each data stream with its own particular data values (temperature and/or pressure in raw and/or EU form), and its own datum conversion format, delivery rate, etc. These augments can also start, stop, pause, resume, or un-define a single stream or *all defined* streams.

The maximum rate of the fastest stream's delivery is practically limited to the maximum possible scan and data conversion rate of the module's single EU pressure and temperature transducer. Normally, the defined streams deliver host data at rates equal to or slower than this natural cycle. Typically, the first stream might deliver only the EU pressure datum, at a high rate (as defined by clock or hardware trigger). The second stream might deliver the EU temperature datum (and a status datum) at a medium rate (some multiple of the clock or hardware trigger period). A third stream might deliver several other "raw" temperature and/or pressure data at an even slower rate (also a multiple of the clock or hardware trigger period).

Because of "legacy" firmware compatibility issues, this command allows "auxiliary" datum values to be delivered by one of two distinct methods:

(1) **"limited" method**: the '00' sub-command uses its *position* field to specify the EU Pressure datum (channel 1) **and** *some* "auxiliary" datum values, which are mapped to unused channels (2-16) per Table 3.1 or 3.6. However, some forms of available "raw" data and status cannot be delivered with this older method**.** Sub-command '05' is not normally used with this method (as it did not exist in early systems).

(2) **"unlimited" method**: the '00' sub-command specifies *only* the EU Pressure datum (channel 1) with its *position* field, and the '05' sub-command is used to specify which of *all possible* datum values (and other additional *status* values) may be included in the defined stream. This better method is more flexible than the "limited" method, as it provides *additional new raw datum formats*, and provides for *additional internal status datum formats* as well. It is also more like the capabilities provided by other NetScanner *scanner* modules.

Command 'c'— Sub-command Index 00: *Configure A Host Delivery Stream*

This sub-command is used to configure the *principal* parameters of each of the three possible concurrent host delivery streams, one at a time. Following this configuration phase, the stream (1, 2, or 3) may be started and stopped with other sub-commands. This *Configure* sub-command's format is:

Command	"**c 00 *st* [[[*p*]*p*]*p*]*p sync per f num***" 'c' is the *command* letter. ' 00' is the *sub-command index* (*ii*) for Configure. ' *st*' is the *stream id* digit (1, 2, or 3). ' *[[[p]p]p]p*' is a 1-4 digit hex *position* field (channel selection bit map), capable of selecting 1-16 internal *remapped* channels as per command **'r'** (see Table 3.1 or 3.6) for providing ***limited*** "auxiliary" datum formats; However, if **only** EU pressure channel 1 is defined here, a sub-command (*ii*=5) provides an ***unlimited*** method of specifying which "auxiliary" data — and *additional status data* — appears in the configured stream. ' *sync*' is *sync type* (0=hardware trigger; 1=clock). ' *per*' is the *period* (if *sync*=0: # of trigger periods or if *sync*=1: delay timer period in msec). ' *f*' is the *format* of each *EU or auxiliary* datum delivered in stream (but not any status datum). ' *num*' is the *number of packets* delivered in stream (0=unlimited/continuous, >0=limited). **NOTE: all parameters are separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter
Autonomous Packet	none generated

Description: Configures a particular *stream* (*st*) to deliver data packets autonomously to the host, with each packet containing *selected acquired data*. A Model 903x module has only one (1) EU pressure input channel. However, its EU Temperature channel, and *limited* other "auxiliary" temperature and pressure data, can be made available to the host by *mapping* them to "unused EU pressure" channels 2-16 (see Table 3.1 or 3.6). These channels may be all specified by a bit map (4-16-bits) encoded as a 1-4 hex digit *position* field ([[[*p*]*p*]*p*]*p*). **This *limited* method is retained for compatibility with "legacy" 903x module firmware, but cannot deliver all available forms of auxiliary data and status data. Alternately, an optional 'c' sub-command (*ii*=05) provides an *unlimited* method of *selecting* available *auxiliary data forms (and status data)* to be included in each stream.** This *unlimited* method is provided if this sub-command (*ii*=00) specifies *only* the one true EU pressure channel 1 in its *position* field.

The individual data packets of the stream may be synchronized with either an external (user-supplied) hardware trigger or a periodic clock interrupt generated inside each module. This choice is made with the *sync type (sync)* parameter (a single digit) where: 0 = synchronize with hardware trigger; 1= synchronize with periodic software clock.

When the **hardware trigger** is used to synchronize **data output** (*sync* = 0), it is assumed that the user would prefer to also synchronize the internal data *acquisition (or scan)* cycle. For this reason, when a stream utilizing hardware trigger is started, the module firmware switches out of the free-running continuous data acquisition mode described earlier. Instead, the module waits in an idle mode until a hardware trigger is received to initiate a host stream output. Only on the receipt of that hardware trigger will the module scan and EU convert all its internal channels. Following completion of the acquisition scan (and EU conversion) cycle, the module will make these data available for delivery to the host. In this manner, users are provided with highly synchronized data acquisition *and* delivery from one or more modules. If a module waits in the idle mode for an extended period of time without receiving a data request, it will periodically initiate its own internal data acquisition cycles so as to update internal thermal coefficients. When all hardware triggered streams are complete (or aborted), an individual module will return to the default mode of continuous scanning and EU conversion.

When the **internal software timer** is used to synchronize host stream output rates (*sync*=1), note that the internal clock frequency variances will result in slightly different timing between modules. Although these differences in timing are slight, they may result in noticeable differences in output timing between modules over a long period of time. If highly synchronized data output is required from multiple modules, the hardware trigger mode should be used, and a method of wiring this user-supplied synchronization line to all modules must be provided.

The *period (per)* parameter is a positive decimal integer count (between 0 and 2147483647) specified with 1 to 10 numeric characters as needed. Its meaning (described in the following table) depends on the *sync type (sync)* parameter described above.

sync	meaning of ***per***
0	number of hardware trigger periods to wait before sending each packet
1	delay period (in milliseconds) to wait between sending each packet **NOTE:** minimum is 10 milliseconds (if *per*= 0 or 1)

The *f* parameter identifies the *format* of each *selected EU or "auxiliary" datum* in each stream packet, and is a single numeric digit. Valid format codes are listed in the following table:

f	converts each internal *selected acquired datum* value from..			max.char.
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
6	single binary float	to	exponential "[-]x.xxxxxxexxx"	13
7	single binary float	to	same (output directly as 4 binary bytes)	4

Unless the EU conversion scalar is altered, returned pressure data will be in units of psi. See command **'v'** (a combination of array 02, coefficient 02, and array 03, coefficient 08) for configuring a Model 903x module to return data in other units.

NOTE: With the exception of binary format 7, all other formats include a leading *space* in each datum delivered in each stream packet.

The *number of stream packets* (*num*) parameter is a positive integer count (between 0 and 2147483647), specified with 1 to 10 numeric digits as needed). If non-zero it sets a finite limit on the number of packets delivered in the host data stream. The value 0 requests "continuous" (unbounded) output packets for the defined host stream.

Example:

- Using the *limited* "legacy" method, configure three (3) separate autonomous host delivery streams for a Model 9038 differential module, and divide the module's "channels" between them. Channel 1 (EU pressure only) must be delivered to host at a 10 Hz rate, channel 16 (EU temperature only) is delivered at half that rate, while the remaining "raw channels" (2,3,4,and 9) are delivered at half the previous rate. All streams are generated continuously and synchronized with the internal clock at 100 msec., 200 msec., and 400 msec. periods, respectively. Data are requested in single precision binary IEEE float format (*f* = 7).

  "**c 00 1 0001 1 100 7 0**"
  "**c 00 2 8000 1 200 7 0**
  "**c 00 3 010E 1 400 7 0**"

  Read responses:
  "**A**"
  "**A**"
  "**A**"

- To similarly acquire data at "relative" rates (1, 2, and 4) using a periodic *hardware* trigger (assumed to also cycle continuously at 10 Hz rate), enter the commands:

  "**c 00 1 0001 0 1 7 0**"
  "**c 00 2 8000 0 2 7 0**"
  "**c 00 3 010E 0 4 7 0**"

  Read responses:
  "**A**"
  "**A**"
  "**A**"

- To use the newer *unlimited method* per sub-command '05', see the example at the end of that sub-command's description.

Command 'c'— Sub-command Index 01: *Start Stream*

This sub-command is used to start the delivery of any previously configured host stream in a module. If the stream started is of "continuous" duration, then it will be necessary to use the Stop Stream sub-command later. Otherwise, the stream will end automatically if a finite number of packets has been specified for it. This sub-command may also be used to resume a previously stopped host stream that has not transmitted all requested data packets. The sub-command's format is:

Command	"**c 01 *st***" 'c' is the *command* letter. ' 01' is the sub-command index (*ii*) for ***Start Stream***. ' *st*' is the *stream id* digit (1, 2, or 3, or 0=*all streams*). **NOTE: all parameters separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter.
Autonomous Stream Packet	"*tssss*[vv][*dddd*[*dddd*]*...*" '*t*' is a 1-byte binary (8-bit) value identifying the *stream* number (1-3). '*ssss*' is a 4-byte binary integer (32-bit, big endian) *packet sequence number*. 'vv' is the [optional] 2-byte binary integer (16-bit, big-endian) *valve status word* that may be specified by the '05' sub-command. ' *dddd*' are the *selected acquired datum* values in the selected format, plus a leading *space* (except *f*=7), that may be specified by the '05' sub-command or in the position field of the '00' sub-command..

Description: This sub-command starts a particular specified host stream (*st*=1-3); or starts *all* configured host streams with a single command (*st*=0). Each autonomous host stream packet begins with a 5-byte fixed-format (binary) data header (*tssss*). The first byte (*t*) identifies the host stream, while a 32-bit unsigned binary sequence number (*ssss*) completes the header. This sequence number will start at the value one (1) for the first packet returned by a stream and increment for each other returned packet of that stream. In the case of a "continuous" data stream, the sequence number may overflow the maximum permissible 32-bit integer value. If this occurs, the sequence number value will wrap around to zero (0) following the largest 32-bit value (4294967295) and then continue to increment by one for each returned packet. The sequence number field is intended to provide a mechanism for host software to ensure that host data stream packets are processed or stored in the order in which they were obtained by the 903x module. Each of the three possible host streams will report their own unique sequence number. Note that if a previously stopped data stream is restarted, the returned sequence numbers will resume with the next number at the point of the stream's termination. The sequence numbers will not restart (at one) if a scan list is temporarily stopped and then restarted. Executing a

stream's *main configure* sub-command ('00') again will reset its sequence number to one. A "limited" stream will terminate once this sequence number equals the requested number of packets for the stream.

For periodic hardware-triggered streams, that are never suspended and resumed after being initially enabled, the sequence number may also serve as a "relative" time stamp if the *period* (in milliseconds) of the hardware trigger is a *constant* and is known.

The *selected acquired data (and status)* in each packet will be ordered according to the rules of the particular method: *limited* (see sub-command '00') or *unlimited* (see sub-command '05') that was used to specify them. The *limited* method returns data from highest specified Channel # to lowest specified Channel#. The *unlimited* method returns any specified status word first (*vv*), followed by each datum (in the order they are defined in the specification table, lowest bit number to highest bit number). Each datum (*dddd*) will be output per the format code specified when the stream was configured (by sub-command '00').

Example:

- Start all the streams configured in the previous example:

  "**c 01 0**"

  Read response:
  "**A**"

  Soon after the response is received, the requested data stream packets will begin arriving in the host at a quantity, content, and rate determined by each stream's own particular current configuration (per the 00/05 sub-command).

Command 'c'— Sub-command Index 02: *Stop Stream*

This sub-command is used to suspend the delivery of any previously started host stream in a module, one at a time or all together, whether the stream was "continuous" or "limited" duration. The sub-command's format is:

Command	"**c 02 *st***" 'c' is the *command* letter. ' 02' is the sub-command index (*ii*) for ***Stop Stream***. ' *st*' is the *stream id* digit (1, 2, or 3, or 0=*all streams*). **NOTE: all parameters separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter.
Autonomous Packet	command stops generation of autonomous packets from the requested stream(s).

Description: This sub-command *suspends* the current "run" of a particular specified host stream (*st*=1-3); or *suspends* the current "run" of "*all configured*" host streams with a single command (*st*=0).

The *suspended* stream may be *resumed* for any new "runs" with the ***Start Stream*** sub-command, as long as that stream remains defined in the module. The ***Clear Stream*** sub-command may be used to un-define a stream. Any stream must first be *reconfigured* with the ***Configure A Host Delivery Stream*** sub-command '00' to be fully *restartable* with the ***Start Stream*** sub-command (i.e., to start again with sequence number = 1 for run's first packet). If the *alternate configure* command (sub-command '05') was part of a stream's configuration process, it need not be executed again to reset the sequence number (and its configuration parameters remain intact).

Example:

- Stop all the streams configured in the previous example:

  "**c 02 0**"

  Read response:

  "**A**"

Command 'c'— Sub-command Index 03: *Clear Stream*

This sub-command is used to "un-define" any previously configured host stream in a module, one at a time, or all together. The sub-command's format is:

Command	"**c 03 *st***" 'c' is the *command* letter. ' 03' is the *sub-command* index (*ii*) for ***Clear Stream***. ' *st*' is the *stream id* digit (1, 2, or 3, or 0=*all streams*). **NOTE: all parameters separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter.
Autonomous Packet	none generated

Description: This sub-command *clears* (un-defines) the particular specified host stream (*st*=1-3); or un-defines "all configured" host streams with a single command (*st*=0). Once cleared, a stream must be reconfigured before it can be restarted. If both the *primary configure* command (sub-command '00') and the *secondary configure* command (sub-command '05') are necessary to fully configure a stream, then both will be required to fully reconfigure the stream once this *clear* command (sub-command '03') is executed.

Example:

- Stop all the streams configured above. Then clear (un-define) only stream 3 and then resume the remaining defined streams 1 and 2:

  "**c 02 0**"
  "**c 03 3**"
  "**c 01 0**"

  Read response:
  "**A**"

Command 'c' — Sub-command Index 04: *Return Information About a Stream*

This sub-command returns current stream configuration information in its response:

Command	**"c 04 *st*"** 'c' is the *command* letter. ' 04' is the *sub-command index* (*ii*) for ***Return Info***. ' *st*' is the *stream id* digit (1, 2, or 3, =0 no allowed). **NOTE: all parameters separated by a *space*.**
Response	**"*st* [[[*p*]*p*]*p*]*p sync per f num*"** '*st*' is the *stream identifier* digit (1, 2, or 3). ' [[[*p*]*p*]*p*]*p*' is a 1-4 hex digit *position* field (channel selection bit map). ' *sync*' is *sync type* character (0 or 1). ' *per*' is the *period* (# trigger periods or delay timer period). ' *f*' is the *format* of the data delivered in stream. ' *num*' is the *number of packets delivered* in the stream. **NOTE: all datum fields separated by a *space*.**
Autonomous Packet	none generated

Description: This sub-command returns current configuration information for a particular stream. Returned values are defined the same as the sub-command parameters of *Configure a Host Delivery Stream* (sub-command 00). Note that the '*num*' field represents the *number of packets returned so far* (= last sequence number returned, or =0 if stream not yet started).

Example:

- Return scan list information for stream I (Model 9038 module assumed).
  "c 04 1"

  Read response:
  "**1 810F 0 20 7 32000**"

Command 'c' — Sub-command Index 05: *Select Data Groups In The Stream*

This sub-command specifies additional configuration options that cause a specified stream to deliver "unlimited" EU or "auxiliary"data, or status data, to host (without restrictions inherent in the re-mapped "unused" channels (2-16) per Table 3.1 and Table 3.6).

Command	"**c 05 *st bbbb***" 'c' is the *command* letter. ' 05' is the *sub-command index* (*ii*) for ***Select Data Groups***. ' *st*' is the *stream id* digit (1, 2, or 3 (=0 not allowed)). ' *bbbb*' is the hex option field (bit map*)* to select which options will be returned in the data stream. (See table) **NOTE: all parameters separated by a *space*.**
Response	**"A"** 'A' is the acknowledge letter.

Description: If this sub-command is never executed for a particular stream, then the single **EU Pressure Datum** is (and optionally any other re-mapped "auxiliary" data are) delivered in that stream following the fixed format binary "stream" header. If only the **EU Pressure Datum** is specified by sub-command '00', this sub-command ('05') provides an improved *unlimited* method of selecting any "auxiliary" data and status data in the stream.

The *bit map values* for parameter *bbbb* (shown in the following table) may be added together to specify *all* the actual data/status groups that will be delivered in each packet of the specified stream. The first table entries, if their "bits" are specified, causes *status* values to be delivered in the stream packet (immediately following the stream header). The third table entry, if specified, causes the **Pressure EU Datum** to be delivered (next), per the specified format (*f*) in the configured stream. The remaining table entries will cause other *auxiliary* data (i.e., raw pressures and EU or raw temperature values, in A/D counts or voltage forms) to also be delivered in each stream packet. That is, each of these *auxiliary* data/status groups is output in the stream packet, if its "bit" is specified, in the order of its table entry. Each other "auxiliary" datum will be in the specified format (per *f*), except any status datum will always be a hexadecimal bit map (16-bit big-endian) .

The *primary configuration* command (sub-command '00') and the *secondary configuration* command (sub-command '05') for a stream are independent of each other. Executing one does not clear or negate the other. However, when a stream is *cleared* (sub-command '03'), both configure commands return to their default "module startup" state.

bbbb (hex)	Data/status group selected for inclusion in stream's packet
0001	**Valve Position Status** (see next table for field format)
0002	**Temperature Status** (reserved for future use)**
0004	(reserved for future use)**
0008	(reserved for future use)**
0010	**Pressure EU Datum** (default if '05' never executed)
0020	**Pressure A/D Counts Datum**
0040	**Pressure Voltage Datum**
0080	**Temperature EU Datum** (degrees C)
0100	**Temperature A/D Counts**
0200	**Temperature Voltage Datum**
0400	(reserved for future use)**
0800	(reserved for future use)**
1000	**Reference A/D Counts Datum** (HASS only)*
2000	**Reference Voltage Datum** (HASS only)*
4000	**Zero A/D Counts Datum** (HASS only)*
8000	**Zero Voltage Datum** (HASS only) *

(**) Note: If this currently undefined item is specified, no datum is returned in the stream for it.

(*) Note: If any of these items are specified for a non-HASS (i.e., Quartz) unit, dummy data values containing zero (0), formatted per *f*, are returned in the stream.

The **Valve Position Status** datum, if specified, is delivered as a two-byte *unitary bit map* integer (16-bit, big endian) with the following possible values (shown in hex below). The data format (*f*) in the Configure sub-command ('00') does not affect it. When selected, this status datum group immediately follows the stream header (*tssss*) in each host stream packet, and precedes any other data selected. States shown are for a bit value of 1=On/True.

status (hex)	State Name
0001	Digital Input State D1
0002	Digital Input State D2
0004	Digital Input State D3
0008	Digital Input State D4
0010	Quasi-Diff. Mode State (9034)
0020	(reserved)
0040	(reserved)
0080	(reserved)
0100	Digital Output State K1
0200	Digital Output State K2
0400	Digital Output State K3
0800	Digital Output State K4
1000	Supply Valve State **K5 (9034, 9038)**
2000	**Generate Valve State K6 (9034, 9038)**
4000	**Zero Valve State K7 (all but 9032)**
8000	**(reserved) Valve State K8**

A **Temperature Alarm Status** datum group is reserved should future implementation require it. Currently, no status word is generated if this bit is set. However, it would follow any other specified status words, before any other datum, if implemented.

Example:

- Using the "unlimited" (sub-command '05') stream configure method, configure stream l to continuously return the **Valve Position Status** field, **EU Pressure**, and **EU Temperature** every 1000 msec. (internal clock sync). Configure stream 2 to also continuously return all other *raw forms* of available auxiliary data every 5000 msec. using same method. Leave stream 3 undefined. Return all data as binary lEEE floats (format 7):

  "c 00 1 0001 1 1000 7 0"
  "c 05 1 0091"
  "c 00 2 0001 1 5000 7 0"
  "c 05 2 F360"

  Read response:

  "A"

  When the streams are subsequently enabled (sub-command '01'), data groups in each stream with the *lowest-bit-numbers (table positions)* selected are delivered first. In this particular stream 1, the **Valve Position Status** datum would be first, followed by the EU **Pressure** datum, and finally the **EU Temperature** datum. In the less-frequent stream 2, the pressure "raw" data (A/D counts, then voltages) come first, followed by the temperature "raw" data items, and finally any other "auxiliary" data items (if it is a HASS differential module that actually provides them). Of course, the standard 5-byte always-binary prefix (*tssss*) that begins all stream packets would precede all these data in each stream (see the Autonomous Packet box in **Start Stream** sub-command (index 01)).

WRITE HIGH PRECISION DATA (Command 'p')

Purpose: Outputs data to the module in the high accuracy format. Use this command with *calibrator* (9034/9038) modules to generate a pressure or sequence of pressures. *Standard* (9032/9033) modules ignore this command.

Command	"**p*fii*[*dddd*]" 'p' is the *command* letter '*f*' is the *format* '*ii*' is the index ' *dddd*' is the [optional] *datum* field (expressed in format *f)* with a leading space character
Response	"**A**" 'A' is the *acknowledge* letter

Description: The format field (*f*) contains a single character to specify the format of the *datum* field. Valid formats are shown in the following table:

f	converts *datum* parameter value (*dddd*) from..			max.char.
0	1-10 digit signed decimal " [-xxx]x.[xxxxxx]"	to	single binary float	13
1	8-digit hex " xxxxxxxx"	to	single binary float	9
2	16-digit hex " xxxxxxxxxxxxxxxx"	to	double binary float	17
5	8-digit hex " xxxxxxxx"	to	long binary integer	9
7	single binary float	to	same (input directly as 4 binary bytes)	4

The *index (ii)* field specifies optional ways of generating pressure as a two digit hex number. Some of these indexes refer to an internal table of pressure values (up to 128 entries). For each pressure value, the table also contains a ramp rate and a hold time. The hold time is set to zero to identify the last entry. A valid pressure table must be defined with the ***Download Internal Coefficients*** **('v')** command before using options which refer to this table. No entries are defined at module power up . See the following table for all available option indexes.

Table 3.4: Output Option Indexes

ii	*Description*
00	*Stop generating a pressure and pneumatically shunt the output port to the reference port. Although the datum* field is not used (and may be omitted) a format specifier (*f*) is still required.
01	Generate a pressure in the minimum time. Specify the output pressure value in the *datum* field using the current engineering units.
02	Set a pressure using the ramp rate selected with the 'v' command. Specify the output pressure value in the *datum* field using the current engineering units.
03	Go to a pressure stored in an internal table of pressures. Specify the table's index value in the *datum* field using an integer value between 0 and 127.
04	Cycle once through the internal table of pressures. Although the *datum* field is not used (and may be omitted) a format specifier (*f*) is still required.
05	Cycle continuously through the internal table of pressures. Although the *datum* field is not used (and may be omitted) a format specifier (*f*) is still required.

After receiving this command, the module will return an acknowledge response and begin driving the output pressure toward the (first or only) requested value. This value, the external volume, and the internal ramp coefficient all affect the time required to actually set the pressure. Query the operational status word with the '**q**' command to determine when the command has completed and the pressure is stable. The requested command is not complete until indicated by the operational status word.

Examples:

- Generate 15.000 psi (in minimum time) in calibrator (9034 or 9038) module:

  "p001 15.000"

  Response:

  "A"

- Generate the 5th stored pressure in table inside a calibrator module:

  "p003 5"

  Response:

  "A"

- Generate all the stored pressures (once) in table inside a calibrator module:

  "p004"

  Response:

  "A"

READ MODULE STATUS (Command 'q')

Purpose: Read status information from a module.

Command	"**q*ii***" 'q' is the *command* letter '*ii*' is the *status* index field
Response	*"**hhhh**"* '*hhhh*' is a 4-digit hex *datum* (or other (**) decimal *datum).*

Description: The optional 2-digit index field *(ii)* chooses a particular status field to be returned. Returned value is described in following table for each index (a third column shows any **'w'** command index for *setting* same option):

Table 3.5: Selectable Option Indexes

ii	***returned value* *4-digit hex or other decimal (**)***	***'w' set index***
00	***Module's Model Number**, as decimal (**) integer (e.g., '903x')*	
01	***Firmware Version Number**, as hex value, expressed internally as integer version * 100 (e.g., hex 0064 (100 decimal) means version 1.00)*	
02	***Power-up Test Status**, as bit map (see table below)*	
03	***Operational Status**, as bit map (see table below)*	
04	***Error Status**, as bit map (see table below)*	
05	***Digital Input Status**, as bit map (see table below)*	
06	***IP Address Resolution**, as hex state: 0000=Static (default), 0001=Dynamic*	*13*
07	***TCP Backoff Delay**, as hex value: 0000=None (default) FFFF=use low-order Ethernet Address*	*14*
08	***TCP/IP Data Field Size Prefix**, as hex state: 0000=None (default)*	*16*
09	***TCP Connect Port**, as hex value (e.g. 2828 (or 9000 decimal), default)*	*17*
0A	***Auto UDP Broadcast@Reset**, as hex state: 0000=No (default), 0001=Yes*	*18*

A 4-digit hex response may represent a 16-bit binary internal value, or a status datum, or bit map. Bit 0 is the least-significant bit. Some responses are returned in a decimal (**) format that represents an internal integer or float. For those marked " hex bit map" the bits may be individually interpreted according to one of the following tables:

***Power-up Test Status Bit Map (ii* = 02)**

Bit	Definition
0	A/D failure
3	Not used with TCP/IP modules
4	DH200 error
5	FLASH initialization data error. All initialized data set to default values and stored in FLASH
6	SRAM error

Operational Status Bit Map (*ii* = 03)

Bit	Definition
0	Power up - set at power-up and cleared by reading this status word
1	Error - set if the error status word is not zero and cleared by reading the error status word
2	Busy - set when busy (while setting a pressure) and cleared when commands are complete
3	Old data - set by reading the current data value and cleared by a new measurement
15	Pressure set - set when generated pressure is within tolerance of setpoint

Error Status Bit Map (*ii* = 04)

Bit	Definition
0	power-up test error
1	internal hardware failure
2	command syntax error
3	command execution error

All bits are cleared after reading the error status.

Digital I/O Status Bit Map (*ii* = 05)

Bit	Definition
0	external input D1
1	external input D2
2	external input D3
3	external input D4
8	external output K1
9	external output K2
10	external output K3
11	external output K4
12	internal valve K5: Supply Solenoid ++
13	internal valve K6: Generate Solenoid ++
14	internal valve K7: Re-Zero Solenoid ++
15	internal valve K8: reserved

++NOTE: bit=0 if particular 903x model has no such valve

Examples:

- Request any NetScanner module's type

  "q00"

  Response indicates that module is a 9034 pressure calibrator

  "9034"

- Request 903x module's Digital I/O Status

  "q05"

  Response indicates that internal Re-zero solenoid K7 (alone) is energized

  "4000"

READ HIGH PRECISION DATA (Command 'r')

Purpose: Returns data for the specified channels using a high accuracy data format.

Command	"***rppppf***" 'r' is the *command* letter *'pppp'* is the *position* field *'f'* is the format specifier
Response	" ***dddd*[*dddd*]*...*" ' dddd' are *datum* values for all the channels requested in position field, each with a leading *space*.

Description: Set the bits in the position field *(pppp)* bit map corresponding to the channels desired. This bit map must be represented with four hex digits. The channel/bit assignments are listed below:

Table 3.6: Position Field Bit Map

Bit	Channel	Definition	
		Quartz Models 9032/9034	**Models 9033/9038**
0	1	Engineering unit pressure (psi) (HASS only)	
1	2	N/A	Raw pressure (counts) (HASS only)
2	3	N/A	Raw temperature (counts) (HASS only)
3	4	N/A	Raw reference (counts) (HASS only)
8	9	N/A	Raw zero (counts) (HASS only)
9	10	Raw pressure (counts)	N/A (HASS only)
10	11	Raw temperature (counts)	N/A (HASS only)
15	16	Transducer temperature (^{N}C) (HASS only)	

The *format* specifier (*f*) determines the format each channel's datum is returned in the response. See other possible formats in the following table:

f	converts each internal response value from..			max.char.
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
6	single binary float	to	exponential "[-]x.xxxxxxexxx"	13
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	same (output directly as 4 binary bytes)	4

Examples:

- Instruct a module to return its EU pressure in decimal ASCII format.

  "r00010"

  Response indicates that the pressure standard reads 1.234000 psi

  " 1.234000"

- Instruct a HASS differential module (9033 or 9038) to return each raw datum and its EU transducer temperature in decimal ASCII format.

  "r810E0"

  Response returns highest channel # (EU Temperature in ^{N}C) first, then all the raw values (in counts): zero, reference, temperature, and pressure.

  " 31.234000 12.000000 28000.000000 16324.000000 32033.000000"

READ INTERNAL COEFFICIENTS (Command 'u')

Purpose: Reads one of several internal values using a high accuracy data format. These values may be calibration coefficients, configuration data, measurements, or the results of internal computations.

Command	*"ufaaii[-ii]"* *'u'* is the command letter. *'f'* is the format of each datum returned in the response. *'aa'* is a hex array field. *'ii[-ii]'* is a single hex index field [or optional contiguous range].
Response	*" dddd[dddd]..."* ' dddd' one or more optional datum fields, each with a leading space character.

Description: The format field *(f)* contains a single digit specifying the format of each datum field in the response. Valid formats are listed in the table below. Some formats may not apply to the specific coefficient requested. For example, a value containing a fractional part will be truncated if requested in an integer format.

f	**converts each internal value from..**			**max.char.**
0	single binary float	to	7-10 digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex " xxxxxxxx"	9
5	long binary integer	to	8-digit hex " xxxxxxxx"	9
6	single binary float	to	exponential "[-]x.xxxxxxexxx"	13

The array field *(aa)* must contain two hex digits to identify the requested array. Valid arrays are listed below:

Table 3.7: Internal Arrays (calibrators only)**

aa	Internal Precision	Description
00	64-bit float	Standard calibration
01	64-bit float	DH200 calibration (**)
02	32-bit integer	Configuration values
03	64-bit float	Configuration values
04	64-bit float	Operating values
05	64-bit float	Pressure table (**)
06	64-bit float	Ramp rate table (**)
07	64-bit float	Hold time table (**)

The index field *(ii)* identifies which elements of the specified array are requested. To specify a contiguous range of values, a one or two digit starting hex index may be followed by a hyphen ('-') and a one or two digit ending hex index. Valid indexes for each array type are listed in the tables below:

Table 3.8: Standard Calibration Coefficients (aa = 00)

ii	Definition		
	Quartz Models 9032/9034	**HASS Models 9033/9038**	**DPT Models 9033/9038**
00	full scale range	full scale range	full scale range
01	zero adjustment	zero adjustment	zero adjustment
02	span adjustment	span adjustment	span adjustment
03	C1	A0	
04	C2	A1	
05	C3	A2	
06	D1	A3	
07	D2	A4	
08	T1	B0	
09	T2	B1	
0A	T3	B2	
0B	T4	B3	

0C	T5	B4	
0D	X0	C0	
0E	Y1	C1	
0F	Y2	C2	
10	Y3	C3	
11		C4	
12		D0	
13		D1	
14		D2	
15		D3	
16		D4	
17		E0	
18		E1	
19		E2	
1A		E3	
1B		E4	
1C		X0	
1D		X1	
1E		X2	
1F		T0	
20		T1	
21		T2	
22		T3	
23		T4	

Table 3.8: DH 200 Calibration (*aa* = 01)

ii	Description
00	full scale range
01	zero adjustment
02	span adjustment
03	M coefficient (counts/psi)
04	B coefficients (counts offset at 0 psi)

Table 3.10: Configuration (*aa* = 02)

ii	Description
00	Standard type: 0 = resonant quartz 1 = HASS 2 = DPT
01	Mode: 0 = absolute 1 = differential
02	Units: 0 = user defined (see aa=03, ii=08) 1 = psi (default)
03	Number of readings required for stability
04	Limit for total readings during stability check
05	Number of iterations while setting pressure
06	Tweak count
07	Frequency counter average (9032/9034)
08	A/D average (9033/9038) (HASS only)

Table 3.11: Configuration (*aa* = 03)

ii	Description
00	Control loop error tolerance (9034/9038)
01	Pressure stability tolerance (9034/9038)
02	Time base frequency (MHz)
03	Gain 0 reference (V)
04	Gain 1 reference (V)
05	Gain 2 reference (V)
06	Gain 3 reference (V)
07	Ramp rate (pressure units/sec) (9034/9038)
08	User defined units multiplier (see aa=02, ii=02)

Table 3.12: Operating Values (*aa* = 04)

ii	Description		
	Quartz Models 9032/9034	**HASS Models 9033/9038**	**DPT Models 9033/9038**
00	Measured pressure		
01	Standard's temperature		
02	Reference pressure for Quasi-Diff.Mode (9034 only)		
03	DH200 pressure (9034/9038)		
04	DH200 temperature (9034/9038)		
05	set point pressure (9034/9038)		
06	set point counts (9034/9038)		
07	N/A	raw pressure	N/A
08	N/A	raw temperature	
09	N/A	raw reference	
0E	N/A	raw zero	
0F	raw pressure	N/A	
10	raw temperature	N/A	
17	N/A	calculated a	
18	N/A	calculated b	
19	calculated c	calculated c	

1A	calculated d	calculated d	
1B	N/A	calculated e	
1C	Calculated To		

Examples:

- Instructs calibrator module to return the ramp rate value in the decimal ASCII format.

  "u00307"

  Response shows ramp rate is configured for 1.0 psi/sec

  " 1.000000"

- Instructs a 903x module to return the Measured Pressure, Standard's Temperature, and Reference Pressure in decimal ASCII format.

  "u00400-02"

  Response:

  " 0.512345 30.00034 14.720056"

DOWNLOAD INTERNAL COEFFICIENTS (Command 'v')

Purpose: Writes one (or more contiguous) coefficients (or other operating control value(s)) to the module.

Command	"**v*faaii*[-*ii*] *dddd*[*dddd*]...**"** 'v' is the *command* letter. '*f*' is the *format* of each datum. '*aa*' is a hex *array* selector field. '*ii*[-*ii*]' is a single hex *index* field [or optional contiguous range]. ' *dddd*' is one [or more] *datum* value[s] to be written [contiguously] into the selected array, [each] preceded by a *space* character.
Response	"**A**" 'A' is the *acknowledge* letter

Description: The format field (*f*) contains a single digit to specify the format of the data field. Valid formats are listed in table below.

f	converts each *datum* parameter value (' *dddd*') from..			max.char.
0	1-10 digit signed decimal " [-xxx]x.[xxxxxx]"	to	single binary float	13
1	8-digit hex " xxxxxxxx"	to	single binary float	9
2	16-digit hex " xxxxxxxxxxxxxxxx"	to	double binary float	17
6	single binary float "[-]x.xxxxxxexxx"	to	exponential	13
5	8-digit hex " xxxxxxxx"	to	long binary integer	9

The *array* selector field (*aa*) must contain two hex digits to identify a particular internal array in which to store the specified data value(s). Valid arrays are listed in **Table 3.7** (see 'u' command).

The index field (*ii*) specifies where, in the specified array, to store the data. To specify a range of values, a one or two digit starting index may be followed by a hyphen ('-') and a one or two digit ending index. The index definitions are listed in **Tables 3.8 - 3.12** (see 'u' command).

The datum field(s) should include values for each index specified. Each datum should always begin with at least one space.

This command stores new datum values into the module's temporary (RAM) memory. To make any changes permanent, the arrays must be copied into non-volatile (FLASH) memory with the '**w**' command (index 07).

Examples:

- Command a Model 9034 absolute quartz calibrator module to operate in the pseudo-differential mode. This command specifies format '0', array '02', index '01', and writes the data value '1'.

  "v00201 1"
  "w0A"

  Response (both commands):

  "A"
  "A"

- Command a Model 903x module to change its user-visible operating units from the default (psi) to kPa units:

  "v00308 6.894757"
  "v00202 0"

  Response (from each command):

  "A"
  "A"

- Command a Model 903x module to restore its operating units to the default (psi):

  "v00202 1"

  Response:

  "A"

SET OPERATING OPTIONS (Command 'w')

Purpose: This command can change a module's default operating option settings, or invoke other special internal functions or operations.

Command	"**w*ii*[*dd*[*eeee*]]**" 'w' is the *command* letter '*ii*' is the *index* '*dd* is the [optional] hex *datum* ' *eeee*' is an [optional] *extra datum* with leading *space*
Response	"**A**" 'A' is the *acknowledge* letter

Description: The *index* field *(ii)* contains two hex digits that identify the specific operation. The *datum* field *(dd)*, when present, contains 2 hex digits. Only one index (14) requires the *extra datum* field *(eeee)*. Valid values are listed in the table below (-- marks a missing *datum* field, and fourth column shows any **'q'** command index for reading same option):

Table 3.13: Index and Datum Fields

ii	*dd*	*Description*	*'q' read index*
00	--	***Execute Internal Self Test.***	
01	--	***Update Thermal Coefficients.***	
02-06	--	*Reserved for factory use*	
07	--	*Store **All Arrays** in non-volatile Flash memory.*	
08	*00-7F* *See Table 3.15*	*Clear (de-energize) **Digital Outputs** whose bits are set in the datum* field bit map	
09	00-7F See Table 3.15	Set (energize) **Digital Outputs** whose bits are set in the *datum* field bit map.	
0A	--	**Re-zero Pressure Standard** (in the differential operating mode). (For standard type=DPT, re-zero the module in the same physical orientation that it will be used)	
0B	--	Reserved for factory use	
0C	--	**Calibrate DH-200** (See Sec. 4.4).	
0D-12	--	Reserved for factory use	
13	00 01	Use **Static IP Address Resolution** (default). Use **Dynamic IP Address Resolution**.	06

14	00 01 02	No **TCP/IP Back-Off Delay** (default). Enable **TCP/IP Back-Off Delay** per Ether.Adrs. Enable **TCP/IP Back-Off Delay** per ***eeee***.	07
15	--	Reserved or factory use	
16	00 01	No **TCP/IP Data Field Size Prefix** (default) Enable **TCP/IP Data Field Size Prefix.**	08
17	00	Set **TCP Connect Port** (=***eeee***)(default=9000).	09
18	00 01	No **Auto UDP Broadcast@Reset** (default). Enable **Auto UDP Broadcast@Reset.**	0A

Table 3.15 describes the *datum* field (*dd*) for digital output *set* and *clear* commands. Bit positions in the data value are assigned to individual outputs. These data values, representing individual bits, may be added to set/clear multiple outputs simultaneously. User control of the internal values is not required for normal operation.

Table 3.15: Data Field (*ii* = 08 and 09 only)

dd	***bit***	***Digital Output***
01	*0*	*External output K1*
02	*1*	*External output K2*
04	*2*	*External output K3*
08	*3*	*External output K4*
10	*4*	*Internal output K5:* ***SUPPLY Solenoid*** *(valve normally unconnected (i.e.,* ***set (ii*=09)** to connect air supply))
20	5	Internal output K6: **GENERATE Solenoid** (valve normally connected (i.e., **set (*ii*=09)** to disconnect generator))
40	6	Internal output K7: **RE-ZERO Solenoid** (valve normally unconnected (i.e., **set (*ii*=09)** to connect reference port))

Examples:

- Command module to turn on the air supply (energize SUPPLY solenoid to connect normally-unconnected SUPPLY valve) — 9034 and 9038 calibrator models only.

  "w0910"

  Response:

  "A"

- Command module to connect standard to pressure generator (de-energize GENERATE solenoid to connect normally-connected GENERATE valve) — 9034 and 9038 calibrator models only.

  "w0820"

  Response:

  "A"

NETWORK QUERY (UDP/IP Command 'psi9000')

Purpose: To determine how many (and which) modules are powered-up and operational on the network.

Command	"**psi9000**"
Response	***"ipadr, ethadr, sernum, mtype, sfwver, connst, ipadrst, lisport, subnet, iparpst, udpast, pwrst,"***

Description: When a **NetScanner™** module receives this broadcast command (by continuously monitoring port 7000) it responds with a broadcast (on port 7001) with an ASCII response containing comma-separated parameters. These are listed in the following table:

parameter	meaning
ipadr	IP Address
ethadr	Ethernet Address
sernum	Serial Number
mtype	Module Type (e.g., 903x)
sfwver	Software Version (e.g., x.xx decimal format)
connst	Connection Status (1=connected, 0=available)
ipadrst	IP Address Status (1=has one, 0=waiting for server)
lisport	IP Listening Port for Connections (default=9000)
subnet	Subnet Mask
iparpst	IP Address Resolution Status (1=uses RARP/Bootp, server, 0=uses static IP Address stored internally)
udpast	UDP Auto Status (1=broadcasts this response automatically after connection possible, 0=only sends response for "psi9000" UDP/IP command.
pwrst	Power Up Status (same a 'q02' command response)

Some special **NetScanner™** module types (e.g., 9816) also add Rack, Cluster, and Slot parameters to the response above.

This uniform network query response allows a client host program to identify, configure, and use any suitable group of modules (for the task at hand) by simply opening a TCP/IP connection between itself and each available module needed.

Example:

- Query all module(s) on the network.

  "psi9000"

  Response(s):
  (see Response above)

RE-BOOT MODULE (UDP/IP Command 'psireboot')

Purpose: To unconditionally "reboot" a specified module.

Command	"**psireboot *ethadr***" where *ethadr* is the Ethernet Address of the specifed module in the following special hex-digit format 'xx-xx-xx-xx-xx-xx'
Response	none (module re-boots).

Description: When a **NetScanner™** module receives this broadcast command (by continuously monitoring port 7000) it responds by restarting its firmware immediately. The result is essentially the same as a power up restart, in that any TCP/IP connection is lost, and the module returns to its normal startup state. The host must wait long enough for the re-boot process to be completed before it can again request a connection to the module.

Example:

- Re-boot a specified module on then network.

  "psireboot 00-E0-8D-00-00-01"

  Response:

  (none)

CHANGE MODULE'S IP ADDRESS RESOLUTION METHOD & RE-BOOT (UDP/IP Command 'psirarp')

Purpose: To change (toggle) the current IP address resolution state (*iparpst*) of a specified module, and then unconditionally "re-boot" it.

Command	"**psirarp *ethadr***" where *ethadr* is the Ethernet Address of the specifed module in the following special hex-digit format 'xx-xx-xx-xx-xx-xx'
Response	none (module re-boots).

Description: When a **NetScanner™** module receives this broadcast command (by continuously monitoring port 7000) it responds by toggling its current ARP method to one of two states: dynamic resolution or static resolution. Then it restarts its firmware. The result is essentially the same as a power up restart, in that any TCP/IP connection is lost, and the module returns to its normal startup state. However, if it used the static resolution method before it received this command, after the reboot it will not have a valid IP Address until an external network server (RARP or BootP) provides it with one. However, executing the command a second time will restore it to using its original statically assigned IP address (after another reboot finishes).

Just as for the "psireboot" command, the host must wait long enough for the reboot process to be completed before it can again request a connection to the module.

Example:

- Reconfigure a specified module on the network so that it uses its "other" IP Address Resolution method — and also re-boot it. Presumably, it knew module's current state (*iparpst*) as result of a recent Network Query response from the module.

  "psirarp 00-E0-8D-00-00-01"

  Response:

  (none)

Chapter 4

Calibration

4.1 Resonant Quartz Standard

NetScanner™ System modules 9032 and 9034 contain a resonant quartz transducer. In this transducer, a bellows converts input pressure to an axial force applied to the crystal resonator. To compensate for thermal effects, the transducer contains another quartz resonator that is sensitive to temperature only. Thus, the transducer has two frequency outputs. One output represents applied pressure, with some temperature effect, and the other represents temperature, with no pressure effect.

The nominal pressure frequency output varies from 40 kHz at zero pressure to 36 kHz at full scale. To measure the pressure period, the reference clock is gated into a 24-bit counter for a number of pressure cycles:

$$T = \frac{C_P}{NF_C}$$

T = pressure period
C_p = pressure counts
N = number of pressure cycles
F_c = reference frequency

The number of pressure cycles, N, is adjusted to optimize resolution with measurement time:

$$
\begin{aligned}
Resolution &= \frac{1}{C_{p\ at\ FS} - C_{p\ at\ zero}}\ 100 \\
&= \frac{1}{NF_c(T_{fs} - T_{zero})}\ 100 \\
&= \frac{1}{N\ 10000000(\frac{1}{36000} - \frac{1}{40000})}\ 100 \\
&= \frac{3.6}{N} \\
Measurement\ time &= NT \\
For\ N &= 2000: \\
Resolution &= \frac{3.6}{2000} = 0.0018\%\ FS \\
Pressure\ Measurement\ Time &= 2000\ \frac{1}{36000} = 56ms
\end{aligned}
$$

The pressure period is related to applied pressure by basic physical principles of vibrating beams:

$$p = C\ (1 - \frac{T_0^2}{T_2})\ \ (1 - D\ (1 - \frac{T_0^2}{T_2}))\ S\ \ + \ Z$$

p = *applied pressure*
T = *pressure period*
C, D, T_0 = *transducer calibration coefficient*
S = *span adjustment*
Z = *zero adjustment*

The nominal temperature frequency output is 172 kHz and varies 50 ppm/^{0}C. To measure the temperature period, the reference clock is gated into the 24-bit counter for a number of temperature cycles:

$$U_t = \frac{C_t}{N\ F_c}$$

U_t = *temperature period*
C_t = *temperature counts*
N = *number of temperature cycles*
F_c = *reference frequency*

The number of temperature cycles, N, is the same number used to measure pressure period. The temperature resolution and measurement time is:

$$
\begin{aligned}
Resolution &= \frac{1}{N\ F_c\ U_t\ 50\ ppm/^0C} \\
&= \frac{1}{N\ 1000000\ \frac{1}{172000}\ 0.00005} \\
&= \frac{344}{N} \\
Measurement\ time &= N\ U_t \\
For\ N &= 2000: \\
Resolution &= \frac{344}{2000} = .17^0C \\
Measurement\ time &= \frac{2000}{172000} = 12ms
\end{aligned}
$$

The temperature induced changes in the quartz pressure resonator and in the pressure mechanism are compensated by adjusting the coefficients C, D, and T_0. To simplify the algorithm, these coefficients are parameterized directly in terms of **u**.

$$
\begin{aligned}
C &= C_1 + C_2\ u + C_3\ u^2 \\
D &= D_1 + D_2\ u \\
T_0 &= T_1 + T_2\ u + T_3\ u^2 + T_4\ u^3 + T_5\ u^4 \\
u &= u_t - u_0 u_0,\ C_1 - C_3,\ D_1 - D_2,\ T_1 - T_5 = calibration\ coefficients
\end{aligned}
$$

Although temperature itself does not enter into the compensation, the transducer's temperature can be determined:

$$
\begin{aligned}
temperature\ ^0C &= y_1 u + y_2 u^2 + y_3 u^3 \\
y_1 - y_3 &= calibration\ coefficients
\end{aligned}
$$

4.2 HASS Standard

Many **NetScanner™ System** 9033 and 9038 modules contain a High Accuracy Silicon Sensor (HASS). In this transducer, the input pressure is applied to a micro-machined silicon sensor. Four piezoresistors, diffused into the diaphragm, are connected to form a Wheatstone bridge. Constant current excitation allows a temperature signal to be derived from the bridge voltage. Instrumentation amplifiers provide high level pressure and temperature outputs. An excitation output allows ratiometric operation. Thus, the transducer has four analog outputs. One represents *pressure*, with a temperature effect, another represents *temperature*, with a slight pressure effect, and the last two represents *excitation* and a reference A/D *zero* reading. All of these signals are digitized with a 16-bit A/D. Typically, 200 measurements are averaged to remove noise.

For the DPT standard type, only zero (z) and span (s) adjustments are needed to recalibrate the transducer.

The zero corrected ratio of the pressure and excitation is computed from the raw measurements:

$$P_r = \frac{P_m - Z_m}{E_m - Z_m}$$

P_r = *pressure signal ratio*
P_m = *raw pressure measurement*
E_m = *raw excitation measurement*
Z_m = *raw zero measurement*

The applied pressure is computed from the pressure ratio:

$$P = (A + BV_r + CV_r^3 + DV_r^3 + EV_r^4)\ S + Z$$

p = *applied pressure*
p_r = *pressure ratio*
$A - E$ = *transducer calibration coefficients*
S = *span adjustment*
Z = *zero adjustment*

The zero corrected ratio of the temperature and excitation is computed from the raw measurements:

$$T_r = \frac{T_m - Z_m}{E_m - Z_m}$$

T_r = *temperature signal ratio*
T_m = *raw excitation measurement*
Z_m = *raw zero measurement*

The temperature induced change in the pressure signal; is compensated by adjusting the coefficients A-E. These coefficients are parameterized directly in terms of T_r :

$$A = A0 + A1T_r + A2T^2_r + A3T^3_r + A4T^4_r$$

$$B = B0 + B1T_r + B2T^2_r + B3T^3_r + B4T^4_r$$

$$C = C0 + C1T_r + C2T^2_r + C3T^3_r + C4T^4_r$$

$$D = D0 + D1T_r + D2T^2_r + D3T^3_r + D4T^4_r$$

$$E = E0 + E1T_r + E2T^2_r + E3T^3_r + E4T^4_r$$

A0 - A4 = calibration coefficients
B0 - B4 = calibration coefficients
C0 - C4 = calibration coefficients
D0 - D4 = calibration coefficients
E0 - E4 = calibration coefficients

Since the temperature signal is derived from the bridge resonance, the temperature output may vary with applied pressure. A cross-sensitivity loop is used to compensate for this effect:

$$T_r = T_r + X_0 + X_1P + X_2P$$

P = pressure (calculated without correction)
X0 - X2 = transducer calibration coefficients

Once T_r has been pressure corrected, the coefficients A - E are re-computed.

4.3 Standard Calibration

The **NetScanner™ System** Intelligent Pressure Standards/Calibrators should be calibrated every six (6) months. During calibration, pressures should be applied with an accuracy of 0.003% FS or better. Pressure Systems, Inc., uses an air piston standard with a calibration traceable to the National Institute of Standards and Technology (NIST).

Zero and span coefficients, stored in the modules' non-volatile memories, are provided for calibration adjustments:

$$P_m = P_s S + Z$$

P_m = pressure measurement
P_s = pressure standard
S = span adjustment (approx. 1.0)
Z = zero adjustment (approx. 0.0)

Configure the module to measure externally applied pressure by energizing internal solenoid for normally-connected Generate valve (K6) and allow at least two (2) hours for warm-up. During calibration, apply at least eleven (11) precision pressures using a high accuracy air piston standard. To determine the zero and span adjustment, fit the modules' measurements to the calibration pressures using a linear regression:

$$P_c = P_m S_{adj} + Z_{adj}$$

P_c = calibration pressure
P_m = pressure measurement
Z_{adj}, S_{adj} = linear regression coefficients

Read the old zero and span coefficients from the module using the '**u**' command. These values are located in array type 0 at index 1 (zero) and at index 2 (span). Calculate the new values:

$$S_{new} = S_{old} S_{adj}$$

$$Z_{new} = Z_{old} S_{adj} + Z_{adj}$$

Use the '**v**' command to send the new values to the module and the '**w**' command to store them permanently in the modules' non-volatile memories.

Orientation of the module is important for zero calibration of 9033 and 9038 modules with standard type=DPT. The zero adjustment should be determined and applied with the module physically oriented in the same position it will be operated.

4.4 DH200 Calibration

The 9034 and 9038 pressure calibrator modules also use a DH200 silicon pressure sensor for rapid control response. Except after replacing the DH200 sensor, calibration should not be required.

To calibrate the DH200 sensor:

- Connect an air supply to the module.
- Install a cap (or closed volume) to the output port.
- Calibrate the DH200 sensor with the '**w**' command, (index 0C).
- Store the new values in the module's non-volatile memories with the '**w**' command, (index 07).

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Chapter 5

Service

5.1 Maintenance

NetScanner™ System Models 903x are designed for rugged use. However, a reasonable amount of care must be taken to prevent contaminants from entering the module. If repair or replacement of components is required, return the module to the factory.

5.2 Upgrading Module Firmware

Models 903x contain electronically reprogrammable memory devices that store the module firmware. Pressure Systems, Inc., will occasionally provide new releases of module firmware to provide enhanced instrument performance. The new firmware may be upgraded by using the host computer or any computer on the TCP/IP network, directly via the module's Ethernet Host Port. A computer with access to the Internet is required to upgrade module firmware from the PSI Internet site. New firmware releases will be provided on DOS formatted diskettes, on a CD-ROM, or through the Internet (World Wide Web) at www.psih.com. The firmware files provided on these diskettes, CD-ROM, or through the Internet can be transferred to the modules by executing the PSI *UDP Query* application, furnished from PSI with your NetScanner™ System. The following steps describe the procedures for upgrading module firmware:

- Verify that the Ethernet cable is connected correctly between the host PC and the interface hub (or 98RK Scanner Interface Rack) and that the Model 9082 communications/power cable is connected between the **NetScanner™ System** module and the interface hub (PSI 9IFC, 90DB, or 98RK).

- If using the Internet, create a sub-directory on your PC, preferably in the same directory with ***UDP Query***, and then proceed to the PSI site (www.PressureSystems.com) to download the new firmware files.

- Turn module power **OFF**, and then **ON**.

- Carry out the following steps to download your new firmware into your module:

NUSS PROGRAM:

Execute the ***Nuss*** application on the host PC (using Windows® 95/98/NT/XP). Select (left click) the module to be updated, right click, and then **Connect** to it. From the same menu box, select "Update Firmware", and follow the screen instructions. These procedures will be explained in detail in **Chapter 7**, using the **Quick Start Procedures**.

After all data has been transmitted:

- The module will program all data to non-volatile memory. After verification of the program cycle, the download program will report the download status and terminate, returning to the main program menu. The program and verification cycle takes approximately thirty seconds.
- Turn module power **OFF**, and then **ON**.
- The **NetScanner™ System** module (with upgraded firmware) is now ready for use.

Chapter 6

Troubleshooting Guide

6.1 Initial Set-up Troubleshooting

Initial module troubleshooting techniques may vary. PSI recommends approaching 903x module troubleshooting in the following sequence.

- First, module operation should be tested to verify that the instrument is operating correctly and has not detected an internal failure.
- After verifying that the module is in good working order, configuration of the host communications hardware and software drivers needs to be checked. Most of this discussion will be directed toward PC compatible host computers.
- After ensuring that the host computer is configured to communicate properly, the interface between the host computer and the **NetScanner™ System** module must be examined. This will be directed toward establishing communications with a single module through the Ethernet (TCP/IP) interface.

If the Model 903x module does not appear to function correctly after the following procedures have been completed, consult the Applications or Repair Department at Pressure Systems, Inc., at 1-800-678-SCAN (7226).

6.1.1 Checking Module Operation

- Verify proper power is present at the module. Measure voltages at the round host connector port. Measure the voltages at pins P and R in accordance with the diagram at **Figure 2.1**. Ensure that the input voltage of +24 VDC @500 mA is present at the connector port.
- Run the module internal self tests as described in **Section 2.8.3.** This is accomplished by connecting the Model 9082 cable (power and communications cable) to the round host connector port and into the interface hub and getting proper power to the hub. If no internal errors are detected, the **OK** LED will remain **ON** after tests are complete.
- Verify the following top panel LED functions:
  - **OK** LED should remain **ON**.
  - **PWR** LED should remain **ON**.
  - **CAL** LED should remain **OFF**.

6.1.2 Checking Host PC Operation

The following should be checked after verifying proper module operation in the above tests. This is used to verify that the host hardware, software drivers, and user test software are configured correctly for **NetScanner™ System** operation.

- Execute the *NUSS* program provided with **your NetScanner™ System** equipment. ***NUSS*** allows your PC to *query* (talk to) any NetScanner™ System module on the network.

- When the application is first started, it sends a *query* message to the network asking for information about all the **NetScanner™ System** Intelligent Pressure modules connected to the network. The application then processes all the responses and displays them. Information available from each module is defined in Chapter 3, in the detailed description of the response returned from the "psi9000" UDP/IP command.

6.1.3 Checking the NetScanner™ System Interface Wiring

Once the **NetScanner™ System** is verified to be operating and the host computer has been configured to communicate properly, the final step is to verify that any additional communications cables are connected correctly (for additional modules). If more than one module is being used, always begin testing with only one unit attached to the network. After communications are verified on the first module, add additional modules and repeat testing procedures.

6.2 Reading Atmospheric Pressure

Once communication is established, leave all pneumatic connections open to atmosphere and use the 'r' command to read ambient pressure. Models 9032 and 9034 contain an absolute pressure standard. The 9034 has a Ref. port, allowing it to be configured to operate in either the absolute or the pseudo-differential mode. Models 9033 and 9038 contain a differential transducer and must be operated in the differential mode only. The ambient pressure should read near 14.7 psia for absolute operation and near zero for differential operation. If the pressure is unreasonable, check the following:

- Read the module configuration from **Array Type 02** using the **'u'** command and compare the values with the table below:

Table 6.1: Array Type 02

Index	Description	Value	
		9032/9034	**9033/9038**
0	Type	0=Quartz	1=HASS 2=DPT
1	Mode	0=Abs 1=Diff (9034)	1=Diff
2	Units	1=psi	1=psi
7	Counter Avg	2000	
8	A/D Avg		200 (HASS only)

- If the module is a 9032 or 9034, read the internal clock calibration from index 2 of **Array Type 03**. (See **Chapter 3, Table 3.11**) The value should be near 10.0 and is recorded on the factory calibration report.

- Read the standard's calibration coefficients from **Array Type 00** (**Chapter 3, Table 3.8: Standard Calibration Coefficients**) and compare to the values shown on the factory calibration report.

Use the '**v**' command to make any required corrections.

6.3 Generating Pressure

Connect a regulated air pressure source to the **SUPPLY** port of a Model 9034 or 9038 and install a blanking cap on the **OUTPUT** port or attach a small closed volume. Set a pressure near full scale using the '**p**' command. Use the '**r**' command to read the actual output pressure. The output pressure should be within 0.01% of the setpoint after 5-10 seconds. If the setpoint is not achieved, check the following:

- Read the module configuration from **Array Type 02** (above, **Table 6.1**, and below, **Table 6.2**) using the **'u'** command and compare values to the table below:

Table 6.2: Array Type 02

Index	Description	Value
3	Stability count	4
4	Max readings	500
5	Iterations	4
6	Tweak count	4

- Read the module configuration from **Array Type 03** (see also **Chapter 3, Table 3.11: Configuration**) using the '**u**' command and compare to the table below:

Index	Description	Value
0	Loop tolerance	100
1	Stability tolerance	.002 x FS

6.4 Leak Check

To achieve high accuracy, pneumatic connections to the output port of a Model 9034 or 9038 must be leak tight. Use the following procedure to check for output leaks:

- Set the output pressure to full scale (xx.xxxx) with 'p' command:
  "p001 xx.xxxx"

- Wait several minutes for the system to stabilize.

- Remove the pressure generator by energizing (disconnecting) the normally-connected Generate valve (K6) and then de-energizing (disconnecting) Supply valve (K5) with '**w**' commands:
  "w0920"
  "w0810"

  This will remove the pressure source and trap the output pressure in a closed volume.

- Monitor the output pressure for several minutes. The pressure decay should be less than 0.05% FS/min.

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Chapter 7

Start-up Software

7.1 Introduction

The **NetScanner™ System Unified Startup Software (NUSS)** allows you to operate, from a Windows®-based host PC, a diverse network of pressure scanner modules and/or standard/calibrator modules of the **NetScanner™ System** type.

The **NetScanner™ System**, for which **NUSS** was designed, is a distributed Ethernet network (using TCP/UDP/IP protocols) that functions as a precision pressure data acquisition system.

NUSS integrates a diverse set of older "startup," "query," and "test" programs that were often very module-specific. **NUSS** recognizes each **Model 9116** module type it finds on the network and automatically provides that module with its appropriate functionality by dynamically adjusting the program's form and menu content. **NUSS** allows you to operate your **Model 9116** modules singly or together in selected groups without having to write any custom software, and without having to learn low-level commands. The software was designed to permit you to test almost every possible module function with a simple interactive point-and-click interface.

NUSS is provided to all customers who have purchased a **Model 9116** Intelligent Pressure Scanners. The software as well as the User's Manual may be downloaded from PSI's Web site, www.PressureSystem.com.

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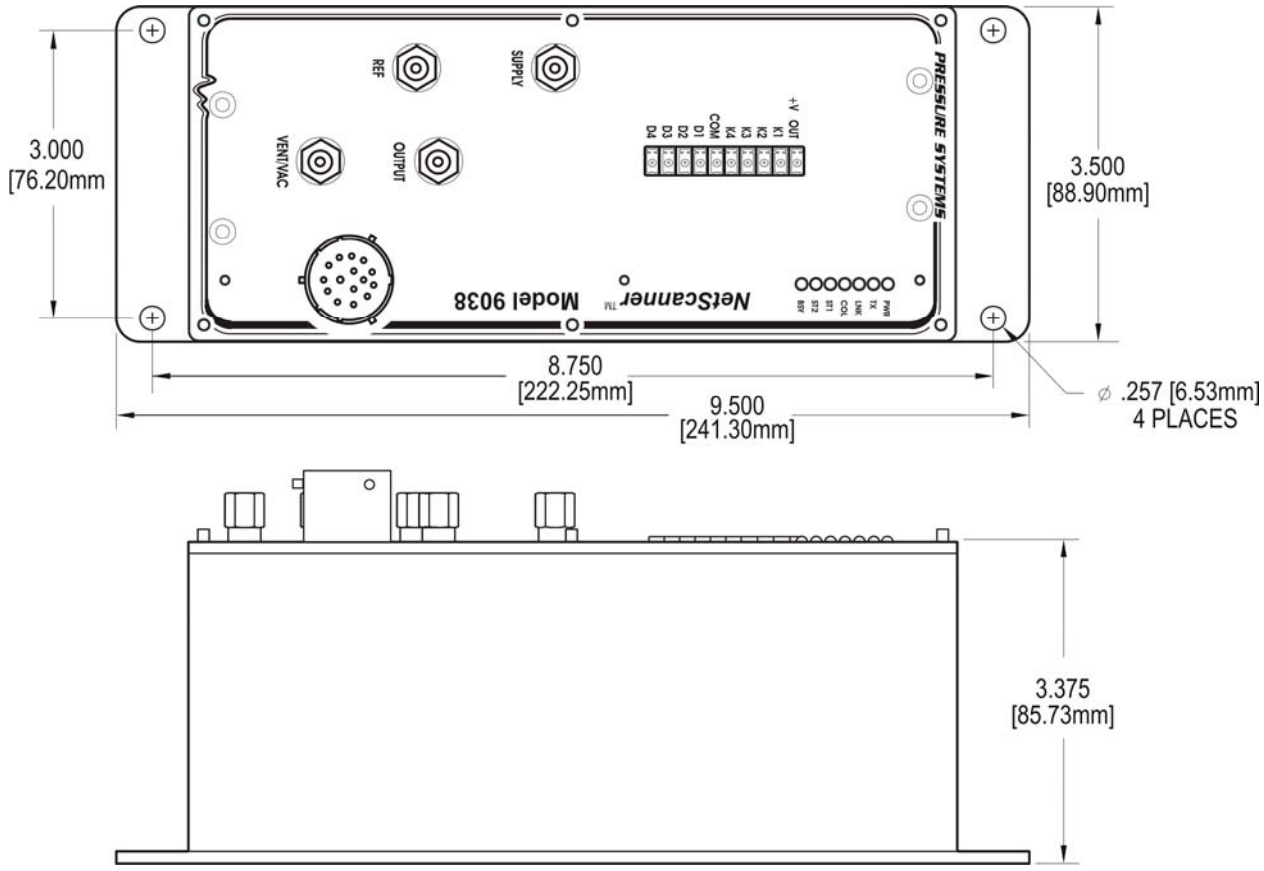
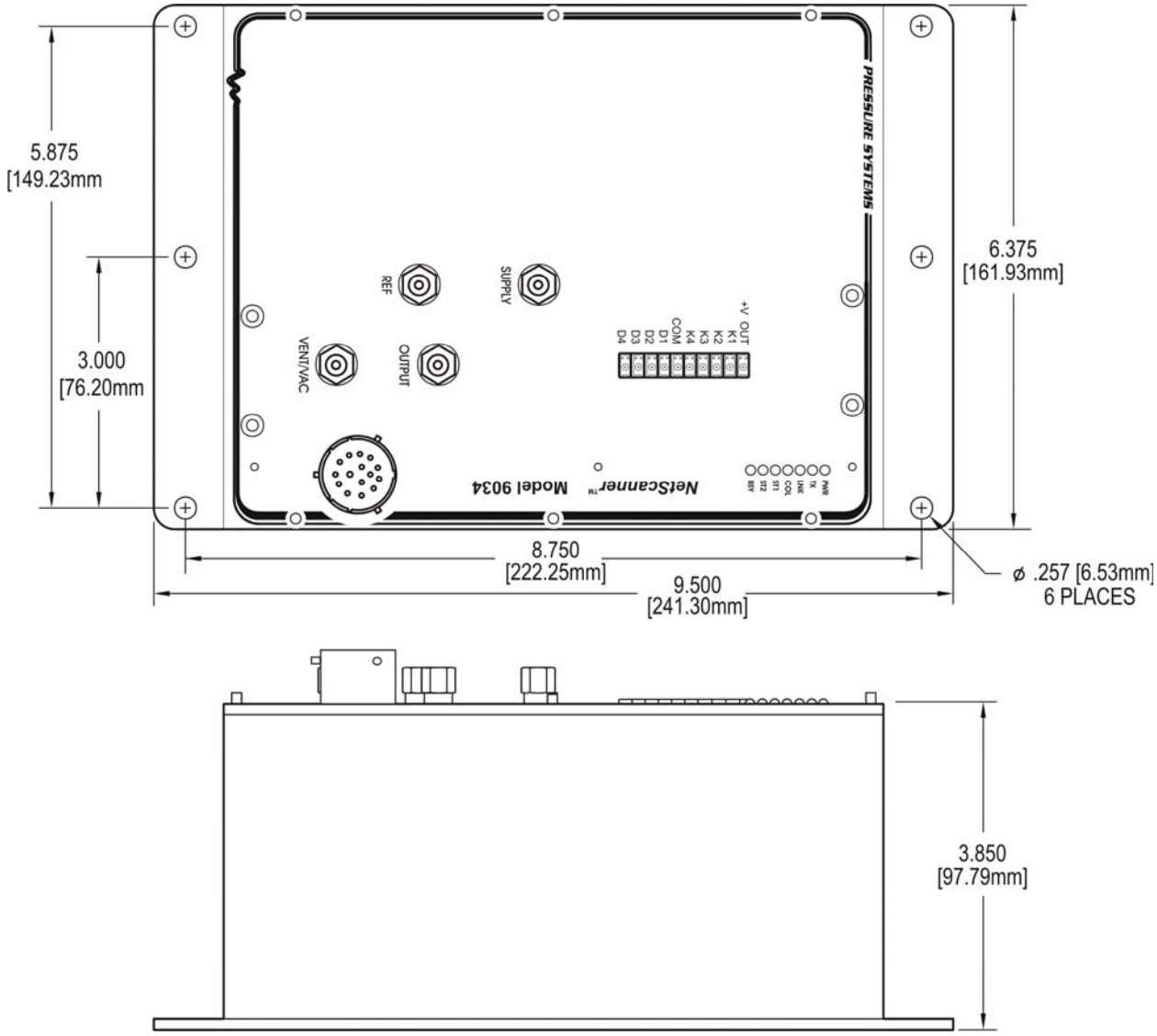
Appendix A

Mounting Dimensions

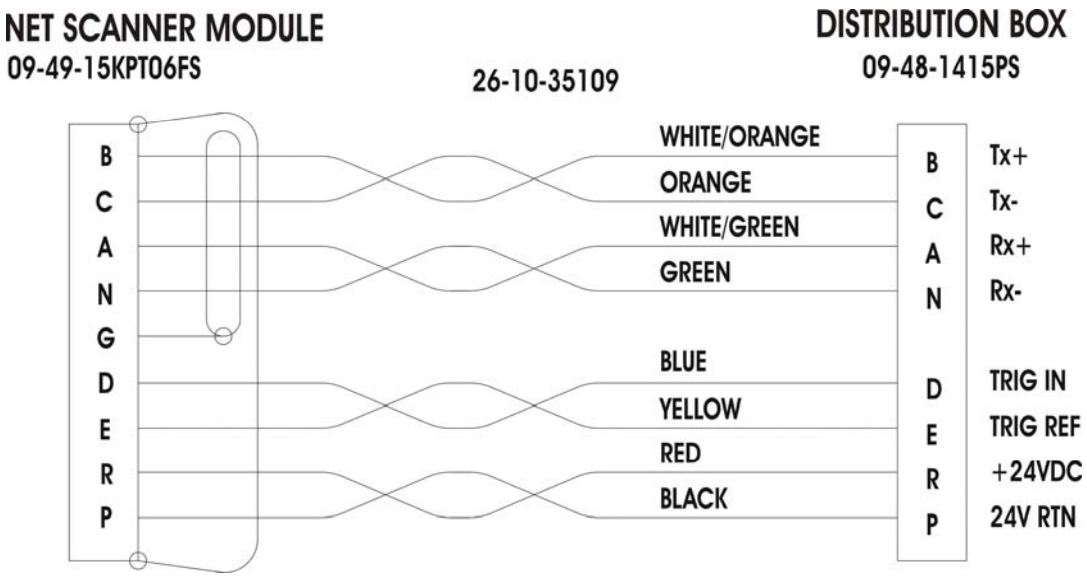


Typical Mounting Dimensions


5.875
[149.23mm
3.000
[76.20mm
6.375
[161.93mm]
8.750
[222.25mm]
9.500
[241.30mm]
ø .257 [6.53mm]
6 PLACES
3.850
[97.79mm]
PRESSURE SYSTEMS
REF
SUPPLY
VENT/VAC
OUTPUT
+V OUT
K1
K2
K3
K4
COM
D1
D2
D3
D4
NetScanner™ Model 9034
PWR
TX
LNK
COL
ST1
ST2
BSY

Appendix B

Cable Diagram



Typical 9082 Cable Diagram

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Appendix C

Quick Reference NetScanner™ System Commands

Letter	NetScanner™ Commands	Command Letter Value	
		Decimal	Hex
A	Power Up Clear	65	41h
B	Reset	66	42h
V	Read Transducer Voltages	86	56h
Z	Calculate and Set Gains	90	5Ah
a	Read Transducer Raw A/D Counts	97	61h
b	Acquire High Speed Data	98	62h
c	Define/Control Host Streams	99	63h
h	Calculate and Set Offsets	104	68h
m	Read Temperature A/D Counts	109	6Dh
n	Read Temperature Voltage	110	6Eh
q	Read 9000 Status	113	71h
r	Read High Precision Data	114	72h
t	Read Transducer Temperature	116	74h
u	Read Internal Coefficients	117	75h
v	Download Internal Coefficients	118	76h
w	Set Operating Options	119	77h

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Appendix D

NetScanner™ System Error Codes

These error codes will be sent as a response to an error condition in the module. Instead of an acknowledge, ('A') or acknowledge with data, a negative acknowledge, 'N' will be sent followed by the error codes listed below.

CODE	MEANING
00	**Power Up Clear Expected — Command Ignored.** A command other than 'A' was attempted after power up or power failure. Once the error is received, it is unnecessary to execute the 'A' command. The next command will be executed normally. **Important** If this error is received, all parameters have been reset to Power Up defaults.
01	**Undefined or unimplemented command**. The command received was not a legal command character.
02	**CheckSum Error.** The checksum received does not match the sum of the characters received.
03	**Input Buffer Overrun.** The received command contained more than 71 characters for analog or 16 for digital or 512 for PSI NetScanner™ System. The command was ignored.
04	**Non Printable ASCII Character Received**. Only characters from 21H to 7FH are permitted within commands. The command was ignored.
05	**Data Field Error.** Not enough characters were received. The command was ignored.
06	**Communications WatchDog Timeout Error.**
07	**Specified Limits Invalid.**
08	**PSI NetScanner™ System Error**

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Appendix E

ASCII Hexadecimal Conversion Chart

DEC	HEX	ASCII	DEC	HEX	ASCII	DEC	HEX	ASCII
65	41h	A	97	61h	a			
66	42h	B	98	62h	b	10	0Ah	LF
67	43h	C	99	63h	c	13	0Dh	CR
68	44h	D	100	64h	d	48	30h	0
69	45h	E	101	65h	e	49	31h	1
70	46h	F	102	66h	f	50	32h	2
71	47h	G	103	67h	g	51	33h	3
72	48h	H	104	68h	h	52	34h	4
73	49h	I	105	69h	i	53	35h	5
74	4Ah	J	106	6Ah	j	54	36h	6
75	4Bh	K	107	6Bh	k	55	37h	7
76	4Ch	L	108	6Ch	l	56	38h	8
77	4Dh	M	109	6Dh	m	57	39h	9
78	4Eh	N	110	6Eh	n			
79	4Fh	O	111	6Fh	o			
80	50h	P	112	70h	p			
81	51h	Q	113	71h	q			
82	52h	R	114	72h	r			
83	53h	S	115	73h	s			
84	54h	T	116	74h	t			
85	55h	U	117	75h	u			
86	56h	V	118	76h	v			
87	57h	W	119	77h	w			
88	58h	X	120	78h	x			
89	59h	Y	121	79h	y			
90	5Ah	Z	122	7Ah	z			

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Appendix F

Binary Bit Map

Bit Value (if Set)	Bit Position	Binary Number			
1	1	0000	0000	0000	0001
2	2	0000	0000	0000	0010
4	3	0000	0000	0000	0100
8	4	0000	0000	0000	1000
16	5	0000	0000	0001	0000
32	6	0000	0000	0010	0000
64	7	0000	0000	0100	0000
128	8	0000	0000	1000	0000
256	9	0000	0001	0000	0000
512	10	0000	0010	0000	0000
1024	11	0000	0100	0000	0000
2048	12	0000	1000	0000	0000
4096	13	0001	0000	0000	0000
8192	14	0010	0000	0000	0000
16384	15	0100	0000	0000	0000
32768	16	1000	0000	0000	0000

Decimal to Binary Conversion:

892 dec = 512 + 256 + 64 + 32 + 16 + 8 + 4

0000	0011	0111	1100	binary
	3	7	C	hexadecimal

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